Assessing the Feasibility of a Central New York Naturally Chilled Water Project

The Research Foundation
The State University of New York

GHD

in association with

EcoLogic GRYPHON ESF HISCOCK & BARCLAY LLP Exponent Central New York Regional Planning & Development Board UFI Upstate Freshwater Institute

Final Report
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1.0 Background and Introduction

1.1 Background

The construction and ultimate success of the Cornell Lake Source Cooling Project (see Section 3) caused community leaders to wonder if a similar project could be mounted in Central New York. The initial concept generated by the community visionaries consisted of a deep water intake in Lake Ontario, a pumping station and pipeline from Oswego to Central New York, use of the naturally chilled water for existing facilities and as an economic attractor for new growth, and ultimate discharge of spent cooling water into Onondaga Lake, with presumed environmental benefits for that body of water.

The concept was presented to then Congressman James Walsh who secured funding, channeled through Region 2 of the Environmental Protection Agency, for the feasibility study presented in this document.

1.2 Project Participants and Organization

A project workplan was generated identifying issues that had to be addressed. The workplan broke the issues into a series of discrete tasks and was submitted to the Environmental Protection Agency for approval. A project team with a wide range of expertise was assembled to address the tasks identified in the workplan. The State University of New York College of Environmental Science and Forestry (SUNY-ESF), working through the Research Foundation of the State University of New York, was assigned the duties of project management. Project team members and their expertise are identified in Table 1-1.

Table 1-1. Central New York Naturally Chilled Water Feasibility Study Project Team Members

Organization	Individuals	Expertise
College of Environmental Science and Forestry, State University of New York, Syracuse, NY 13210	James M. Hassett, Ph.D.	Project Director
	Neil Ringler, Ph.D.	Fisheries biology
	Kimberly Schulz, Ph.D.	Aquatic ecology
	Anthony Siniscal, M.S.	Fisheries biology, Administrative assistant

Table 1-1. Central New York Naturally Chilled Water Feasibility Study Project Team Members (Continued)

Organization	Individuals	Expertise
Stearns & Wheler GHD, 1 Remington Park Drive, Cazenovia, NY 13035	Wayne E. McFarland, P.E., DEE	Environmental engineering and management
	Kevin Castro, P.E.	
	Timothy Carpenter, P.E.	
	Allison Muehe, E.I.T.	
Ecologic,[a] LLC. Atwell Mill Annex, Suite S-2 132 1/2 Albany Street Cazenovia, NY 13035	Elizabeth Moran, Ph.D.	Limnology, environmental permitting
GIE Niagara Engineering[b], Inc. 80 King Street Suite 404 Corbloc St. Catherine, Ontario, Canada L2R 7G1	John V. Heintz, P.E., C.E.	Engineering aspects of lake water cooling systems
	Peter R.Veldhuizen	
Metropolitan Water Board 4170 Rt. 31 Clay, NY 13041	Ferdinand Picardi, Esq.	Public water supply agency
	David Fitch	
The Central New York Regional Planning and Development Board (CNY RPDB) 126 North Salina St., Syracuse, NY 13202	David Bottar, Executive Director	Regional economic analysis and planning
	Michael Rosanio	
	Chris Carrick	
Hiscock & Barclay 221 South Warren Street, Syracuse, NY 13221-4878	Andrew Leja, Esq.	Environmental law
Exponent, 420 Lexington Ave., Suite 1740, New York, NY 10170	Betsy Henry, Ph.D. Managing Scientist	Regulatory compliance
Upstate Freshwater Institute P.O. Box 506 Syracuse, NY 13214	Steven Effler, Ph.D. Director of Research	Water quality and hydrodynamic modeling
	David Matthews, Ph.D.	
Research Foundation of the State University of New York (at SUNY-ESF)	William J. Nicholson	Research account management
	Cheryl A. Liptak	
USEPA Region 2 Strategic Planning Multi-Media Programs Branch, 290 Broadway, New York, NY 10007	Lorne LaMonica	Project coordinator

a. Subcontractor to Stearns and Wheler GHD

b. Subcontractor to Stearns and Wheler GHD

1.3 Organization of the Report

This report is organized into sections. The sections can be grouped as shown in Table 1-2, which also identifies the principle contributors to each section.

Table 1-2.Report Organization

Report Section(s)	Topics Covered	Authors
2	Executive Summary	SUNY-ESF
3	Review of two existing naturally chilled water systems	Stearns and Wheler GHD
4, 5, 6, 7, 8	Review of economic factors, energy usage related to a naturally chilled water system, and potential customers for such a system	The Central New York Regional Planning and Development Board
9, 10	Discussion of energy considerations of a naturally chilled water system, and needs of potential customers	Stearns and Wheler GHD
11	Review of potable water systems in Central New York	Stearns and Wheler GHD
12	Ecological considerations with respect to source of naturally chilled water	SUNY-ESF, Ecologic
13, 14, 15, 16	Engineering and cost aspects	Stearns and Wheler GHD
17	Air quality and energy saving benefits	SUNY-ESF
18	Sensitivity analysis	The Central New York Regional Planning and Development Board
19, 20, 21, 22	Ecological considerations related to source and receiving waters	SUNY-ESF, Ecologic, Exponent, Upstate Freshwater Institute
23	Potential ecological impacts related to construction of a naturally chilled water system	Stearns and Wheler GHD
24, 25	Legal and regulatory considerations	Hiscock & Barclay

The entire document can be accessed at http://www.cnycwp.com.

1.4 Disclaimer

The views and opinions presented in this report are those of the project team. The Project Director was responsible for the creation of this report and is responsible for any errors.

Questions may be addressed to the Project Director.

Although the information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement XA-97264106-0 to the Research Foundation of the State University of New York, it does not necessarily reflect the views of the Agency and no official endorsement should be inferred.

2.0 Executive Summary

2.1 Section Introduction

The important findings of the feasibility study are presented in this section. Parenthetical references identify sections of the report where supporting narrative and data can be found.

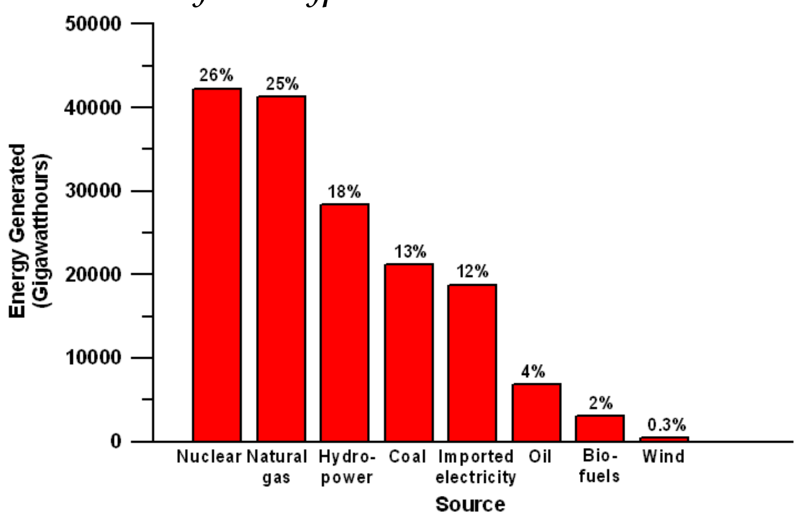
2.2 Cooling Requirements in Central New York

The cooling required for most buildings is supplied by mechanical chillers. These chillers use electricity to cool fluids (typically water), which in turn cool the air in the building. One reasonable estimate indicates that, for the Central New York region, costs for electricity to power mechanical chillers runs about $6.5 million dollars annually (Section 9).

Replacing mechanical chillers with less energy intensive cooling systems would therefore save energy costs, reduce electricity demand, especially during the warmest months, and, depending on the source of electricity, reduce greenhouse gas emissions.

There are other potential benefits. New York State imports about 12% of its electricity, which represents a significant flow of money out of the state (Figure 2-1). Any savings in electricity usage would be reflected in a reduction of the flow of dollars out of state (see Section 5).

Figure 2-1. Energy Generation by Fuel Type- New York State



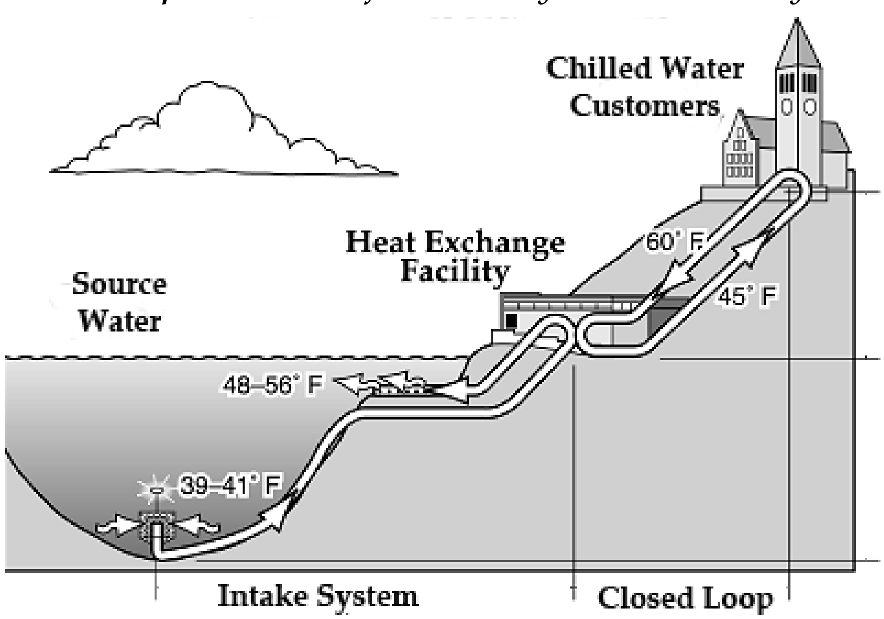
The potential energy savings drove Cornell University and the City of Toronto to investigate and install Naturally Chilled Water systems to provide cooling and replace mechanical chillers. In turn, the success of the two projects was the primary motivation for this feasibility study.

2.3 Components of a Naturally Chilled Water System

Figure 2-2 shows schematically the components of a Naturally Chilled Water system. The components are described below.

- A body of source water (usually a lake) sufficiently large and deep so as to provide a reliable source of naturally chilled water at about 40 ^{O}F.
- A deep water intake device capable of accepting the required flow without adversely affecting the source water's aquatic community.
- A submerged pipeline capable of carrying the required flow from the intake structure to an onshore facility.

Figure 2-2. Schematic Representation of a Naturally Chilled Water System



- A heat exchanger, which is a specialized device that transfers heat from one fluid to another. In this case, heat from water in a closed loop connected to building cooling systems is exchanged with the naturally chilled lake water. The lake water becomes warmer, and the water in the closed loop becomes cooler and is returned to the building cooling systems. As suggested by the schematic, the lake and closed loop water are kept separate and do not mix in the heat exchanger.

- A discharge system by which the now warmer lake water is returned to the environment.
- The closed loop pipeline system by which the cooled closed loop water is cycled between building cooling systems (where it accepts heat and becomes warmer) and the heat exchange facility (where it rejects heat and becomes cooler).
- Customers for chilled water, the fees for which offset the project's construction and operations and maintenance (O&M) costs.

A Naturally Chilled Water (NCW) system requires energy for pumping water from the source body to the heat exchanger, and also for pumping water in the closed loop. A net energy benefit occurs when the total energy requirements for the NCW system are less than the energy required by mechanical chillers to produce the same amount of cooling.

The schematic indicates the system components are in relatively close proximity. In general, this need not be the case. Source water could be pumped for tens of miles before encountering the heat exchanger. Likewise, the closed loop could run several miles from the heat exchanger to the chilled water customers. In these cases, the NCW energy costs are likely to be higher, and therefore the net energy benefit lower, than NCW systems where the components are in close proximity.

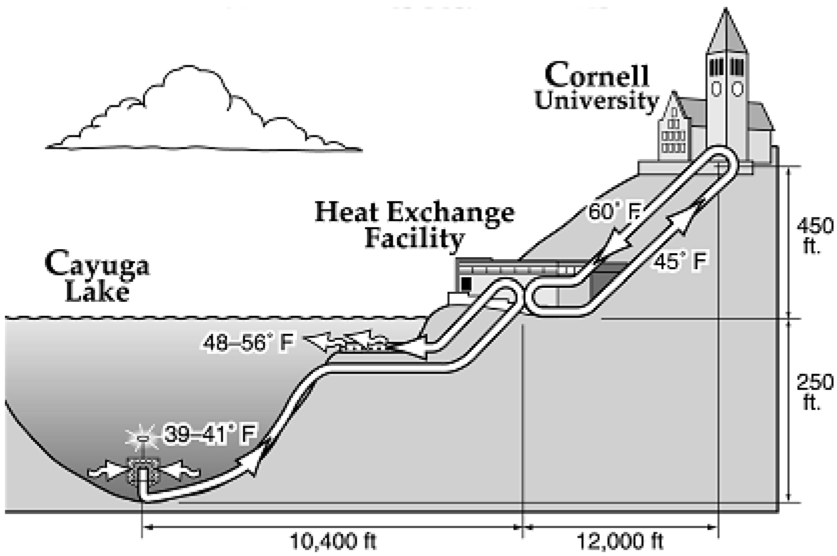
2.4 Review of Two NCW Systems

The project team examined two successful NCW systems to provide guidance as to the feasibility of a Central New York NCW system (see Section 3).

2.4.1 The Cornell Lake Source Cooling System

Figure 2-3 is a schematic representation of the Cornell NCW system, known as the Cornell Lake Source Cooling (LSC) project. Lake water enters the system via a screened intake structure at depth of 250 feet (76 m). The intake pipeline is 10,400 feet (3.17 km) long, 63-inch diameter and made of high density polyethylene (HDPE). The heat exchangers are located in a building along the shoreline of Cayuga Lake.

Figure 2-3. Schematic of Cornell University Lake Source Cooling Project



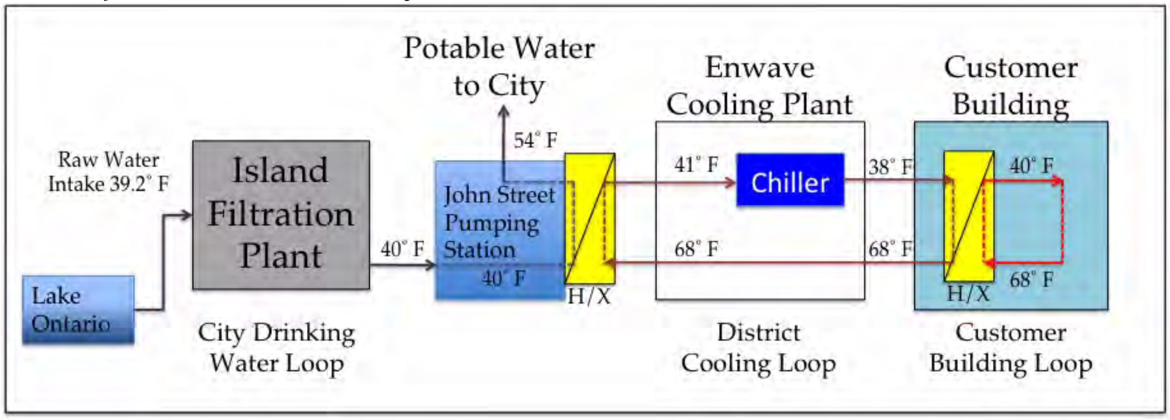
The Cornell system provides a passive and technologically simple cooling option, utilizing a natural, non-polluting, and renewable resource. Electric energy use dropped to ~13% of that required by the original campus cooling system which represents a savings of over 25 million kilowatt hours on an annual basis.

2.4.2 Toronto Deep Lake Water Cooling System (DLWC)

The Toronto DLWC system represents a variation on the general idea of a Naturally Chilled Water system. In the Toronto system, the chilled water from the intake is treated at a water treatment plant and distributed as potable water to Toronto customers. A fraction of the chilled potable water is sent to a heat exchange (H/X) facility. The chilled potable water accepts heat energy from the closed loop and is then utilized as potable water. Thus, a fraction of the potable water is used first for its thermal properties and then as potable water. Positive steps are taken to prevent the potable water from coming in contact with the closed loop cooling water.

Figure 2-4 shows a schematic of the Toronto Deep Lake Water Cooling system.

Figure 2-4. Schematic of the Toronto Deep Lake Water Cooling System Showing Relationship to Potable Water System.



Note: Enwave is the for-profit corporation that manages the cooling district.

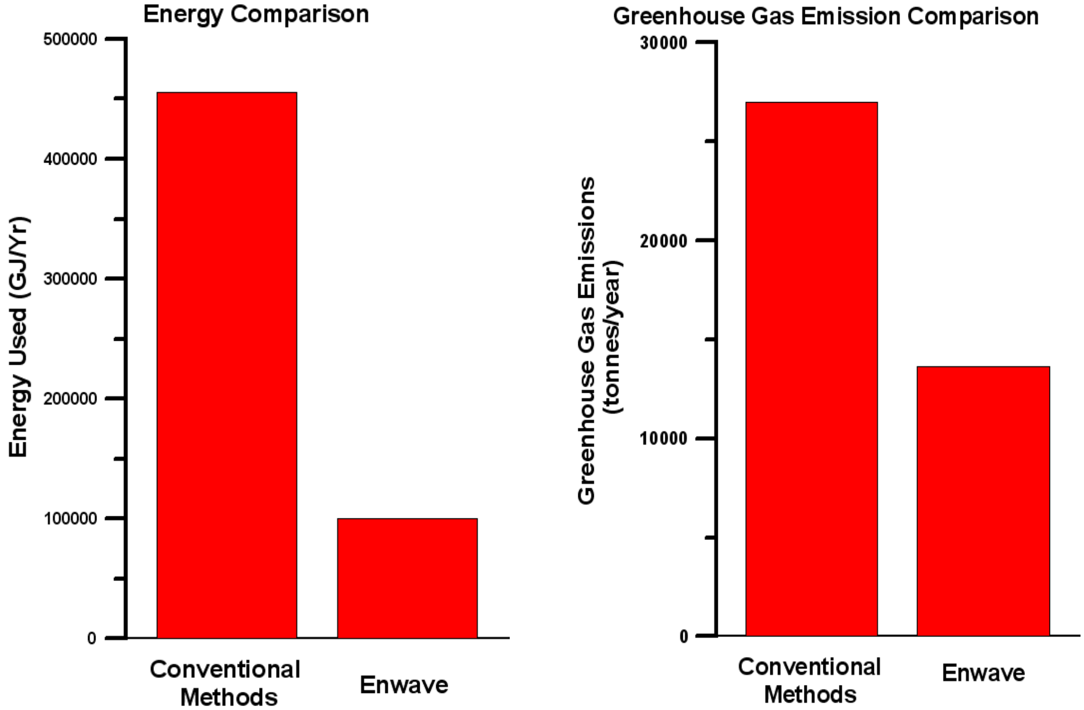
In Figure 2-4, H/X represents heat exchanger. Chiller represents a mechanical chiller that is used occasionally during the peak cooling season summer months.

Some of the benefits attributed to the Toronto DLWC system are listed below.

- Provides air-conditioning to residential, commercial, retail, institutional, governmental buildings and major sports facilities.
- Price-competitive service is sustainable, clean, and renewable.
- Reduces strain on electricity infrastructure, including the transmission grid.
- Reduces electricity usage by 90 percent compared to a conventional cooling system. The system uses 85 million kilowatt-hours per year less than a conventional cooling system.
- 79,000 tonnes (87,000 tons) of carbon dioxide are removed from the air annually (based on the displacement of coal and a full system build out) - equivalent to taking 15,800 automobiles off the road.
- Removes 145 tonnes (160 tons) of nitrogen oxide and 318 tonnes (350 tons) of sulphur dioxide from the atmosphere relative to the use of coal-fired electricity.

Some the Toronto DLWC system benefits are shown graphically in Figure 2-5.

Figure 2-5. Benefits of Toronto System in Terms of Energy Consumption (left) and Greenhouse Gas Emissions (right)



2.4.3 Summary - Review of Two Existing NCW Systems

The Cornell and Toronto naturally chilled water systems provide important guidance to the project team.

- The Cornell system demonstrates the feasibility of a Central New York finger lake as a source of naturally chilled water.
- The Cornell system configuration illustrates the benefits of separate systems for chilled and potable water.
- The Toronto system demonstrates the feasibility of a Lake Ontario source for naturally chilled water.
- The Toronto system demonstrates the feasibility of, and safeguards appropriate for, a chilled water system utilizing treated water first for its thermal properties and then as potable water.
- Both systems illustrate the availability of robust mechanical and control equipment as system components.

2.5 Review of Central New York Water Distribution Infrastructure

2.5.1 Background

The project team reviewed the water distribution infrastructure that exists in Central New York. The purpose of the review was to learn of and evaluate opportunities to use existing infrastructure so as to minimize project construction and operations and maintenance (O&M) costs. Important components of the existing infrastructure are shown schematically in Figure 2-6.

Our review found that both Lake Ontario and Skaneateles Lake are potential sources for naturally chilled water. (Otisco Lake is too shallow to provide a consistent source of chilled water). The Lake Ontario source could supply naturally chilled but non-potable water in parallel with the existing potable water infrastructure. In this case, the chilled water system would be similar to the Cornell Lake Source Cooling system, in that potable and non-potable systems would be completely separate (Figure 2-3).

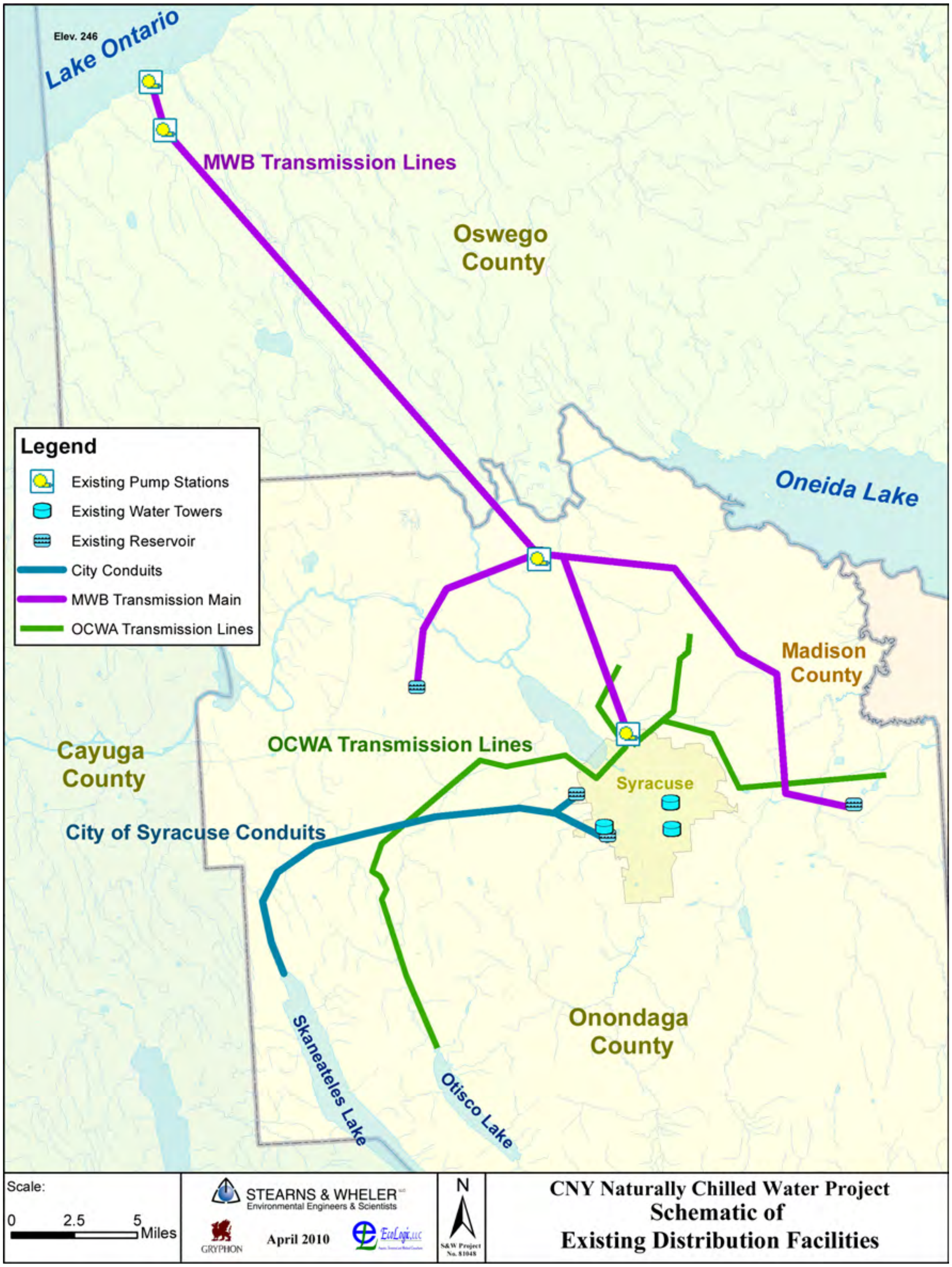
Either Lake Ontario or Skaneateles Lake could provide naturally chilled water through its existing potable water system infrastructure, in a system configuration similar in general to the Toronto Deep Lake Cooling System (Figure 2-4).

For either source water and/or system configuration, a chilled water system would include the following components.

- Intake structures at the depth necessary to withdraw naturally chilled water from either lake source.
- Water transmission pipelines and pump stations to convey the naturally chilled water to a heat exchanger.
- Return pipelines to discharge water from the heat exchangers to an appropriate outfall (in the case of non-potable water) or back into the potable water system (in the case of potable water).

Chilled water customers would be served by a closed loop conveying water from the heat exchanger to users, and back to the heat exchanger. This closed loop is separate and distinct from the potable water system. Water in this loop is not potable water, and the system would be designed to prevent mixing of potable and non-potable water.

Figure 2-6. Schematic of Existing Water Distribution Infrastructure in Oswego and Onondaga Counties



2.5.2 Comparison of Two Potential Lake Sources

Information pertinent to Lake Ontario and Skaneateles Lake as NCW source water is presented in Table 2-1 (see Section 11 for further information).

Table 2-1. Comparison of Lake Ontario and Skaneateles Lake as Potential Source of Naturally Chilled Water

Project Consideration	Potential Naturally Chilled Water Source	
	Lake Ontario	Skaneateles Lake
Water surface elevation	245 ft (75 m) above sea level	863 ft (263 m) above sea level
Intake location and depth	Approximately 18,000 feet (5.5 km) long at a depth of 250 feet (76 m). The intake would be off Burt Point, Oswego, NY.	Approximately 19,700 feet (6.0 km) from the northern shoreline at a depth of approximately 135 feet (41 m).
Water temperature at intake location	Approximately 39°F (4°C) year round.	Approximately 42°F (5.6°C) year round.
Intake structure	Screen with 2 mm mesh	Screen with 2 mm mesh
Intake pipeline	63 inch diameter HDPE	63 inch diameter HDPE
Hydraulic capacity of intake pipeline	47 million gallons per day (mgd)	47 mgd

The information in Table 2-1 indicates both Lake Ontario and Skaneateles lake can be a reliable source of naturally chilled water. A water withdrawal from Skaneateles Lake would flow by gravity to the Syracuse area (approximate elevation 400 ft (120m) above sea level); water withdrawn from Lake Ontario would have to pumped uphill to the Syracuse region, with attendant capital and energy costs.

The project team moved forward with an assumption that either source could provide 30 mgd for cooling. This choice allowed both sources to be compared at the same rate of chilled water flow, and is consistent with requirements calculated for a range of potential chilled water customers (see Section 8).

2.6 Options for a Central New York Naturally Chilled Water System

The project team identified five options for further study. The options include one or the other source lake, and different degrees of overlap with existing water distribution infrastructure. The important features of the options are listed below, and shown schematically in Figures 2-7 through 2-11.

All options are based on transport of chilled water to the University Hill/ Downtown Core for cooling use, as this area of the county has the highest density of potential chilled water customers (see Section 10).

2.6.1 Option 1: Original Concept

Lake Ontario intake with new (non-potable water) transmission pipeline, heat exchange facility in the city, outfall to Onondaga Lake. In this option, an entirely new chilled water delivery system would be constructed adjacent to the existing MWB clearwater transmission line and within the same rights-of-way.

- New intake on Burt Point to provide a chilled water flow of 30 mgd.
- New influent pumping station to provide the energy needed to move the water from the intake wet well to the heat exchange facility.
- New 42-inch diameter transmission pipeline from Oswego to Seventh North Street in Syracuse.
- New heat exchange and pumping facility located near the Seventh North Street pump station.
- New chilled water loop from the Seventh North Street site to Syracuse University chilled water plant, 36-inch diameter.
- New 54-inch diameter outfall to Onondaga Lake.
- Water would not be used for potable water supply before or after thermal harvesting.
- The new pipeline could serve as a backup water transmission main for MWB in the event of an emergency, but would require a boil water notice to consumers to be utilized in this fashion.

2.6.2 Option 2

Lake Ontario intake utilizing existing Metropolitan Water Board pipeline segments; heat exchange facility near Terminal Reservoir.This option shares use of existing infrastructure where available and adds new components where needed. A new heat exchange facility to be located near Terminal Reservoir would be a key component of this option. A closed water loop from the heat exchange facility to the Syracuse University chilled water plant would need to be constructed.

- New intake on Burt Point to provide a chilled water flow of 30 mgd.
- New transmission line segment from Burt Point to the existing MWB water treatment plant in Oswego.
- New influent pumping station to provide the energy needed to move the water from the intake wet well to the existing MWB water treatment plant in Oswego.
- Raw water treated to potable standards at the existing MWB treatment plant in Oswego.
- Shared use of the existing 54-inch diameter clearwater transmission pipeline from the water treatment plant to the new heat exchange facility near Terminal Reservoir.
- New closed chilled water loop between the heat exchange facility and the Syracuse University chilled water plant, 36-inch diameter.
- New chilled water pumping station sized for 30 mgd, located at the heat exchange facility.
- Economic benefits from the water would be increased, since it would be sold once for cooling and once for potable use.
- Potable water transferred to Terminal Reservoir after thermal harvesting.
- New outfall to Oneida River for any periods when cooling water demand exceeds potable water demand.

2.6.3 Option 3

Lake Ontario intake utilizing existing Metropolitan Water Board pipeline segments; heat exchange facility near Seventh North Street. This option shares use of existing infrastructure where available and reduces the length of the chilled water loop. A closed chilled water loop from the heat exchange facility to the Syracuse University chilled water plant would need to be constructed.

- New intake structure at Burt Point to provide a maximum flow of 30 mgd.
- New transmission line segment from Burt Point to the existing MWB water treatment plant in Oswego.
- New lake water pumping station to provide the energy needed to move the water from the intake wet well to the existing MWB water treatment plant in Oswego.
- Raw water treated to potable at the existing MWB water treatment plant in Oswego.
- Utilize the existing 42-inch diameter clearwater transmission pipeline from the water treatment plant to Terminal Reservoir.
- New bypass piping segment, 54-inch diameter, from just before Terminal Reservoir to the Seventh North Street pump station.
- New heat exchange facility near the Seventh North Street pump station initially sized for 30 mgd.
- New closed chilled water loop between the heat exchange facility and the Syracuse University chilled water plant, 36-inch diameter.
- New chilled water pumping station sized for 30 mgd, located at the heat exchange facility.
- Potable water transferred by a new pump station to the Eastern Branch of the existing MWB transmission system after thermal harvesting by pumping along a new transmission segment along the New York State Thruway corridor.
- New outfall to Onondaga Lake.

2.6.4 Option 4

Skaneateles Lake intake utilizing existing city pipeline segments; heat exchange facility near the Westcott Reservoir. This option makes use of existing infrastructure where available and adds new components where needed. A new closed chilled water loop from the heat exchange facility to the Syracuse University chilled water plant would need to be constructed.

- New intake structure to provide a chilled water flow of 30 mgd.
- New low lift lake water pumping station to provide the energy needed to move the water from a new intake wet well to the existing wet well where existing water distribution conduits lead to the city.
- Utilize the existing conduits to transport lake water by gravity flow to the new heat exchange facility near Syracuse.

- Lake water treated to potable standards by chemical addition at the existing city treatment facilities.
- New closed chilled water loop and pumping station between the heat exchange facility and the Syracuse University chilled water plant (approximately 3 miles (5 km) each way), 36-inch diameter.
- Potable water returned to city reservoirs after thermal harvesting.
- Economic benefits from the water would be increased, since it would be sold once for cooling and once for potable use.
- New outfall to Onondaga Creek, to be used only rarely when cooling demand exceeds potable water demand.
- City potable water demands in excess of 47 mgd would be supplied by use of the new (30 mgd) and existing intakes in Skaneateles Lake.

2.6.5 Option 5

Skaneateles Lake intake utilizing existing city pipeline segments, with a connection to potable water from Lake Ontario. Option 5 combines attractive portions of two previously considered options. Option 5 proposes to use the existing infrastructure of both Skaneateles Lake and Lake Ontario to provide the chilled water benefit proposed by Option 4, while increasing the redundancy of the City of Syracuse water by adding new components to the MWB system.

- New intake structure to provide a chilled water flow of 30 mgd.
- A new wet well in Skaneateles to transfer lake water to the existing conduits.
- A new heat exchange facility near Syracuse.
- A new main transmission line connecting the MWB Western Branch pipeline to the city distribution system near the city reservoirs. This main transmission line is called the Southwest Branch and has been considered in previous studies to provide redundancy to the city water system.
- Skaneateles Lake water flow to Syracuse would be set to a steady 30 mgd.
- MWB supply to the city potable water supply would increase by 5 to 20 mgd, flowing through the existing distribution network.

The options are shown schematically on the next five pages in Figures 2-7 through 2-11.

Figure 2-7. Schematic of Naturally Chilled Water - Option 1

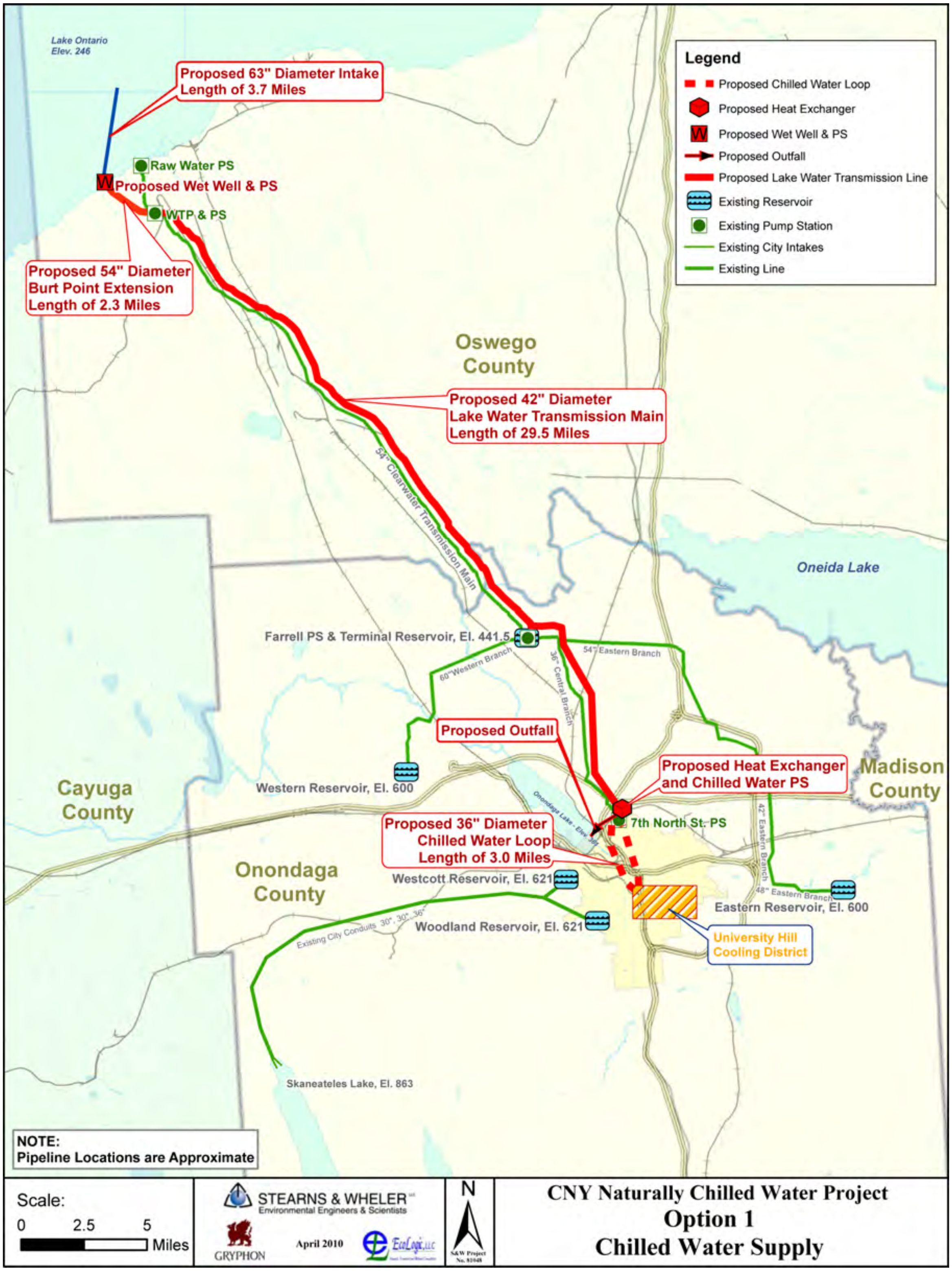


Figure 2-8. Schematic of Naturally Chilled Water - Option 2

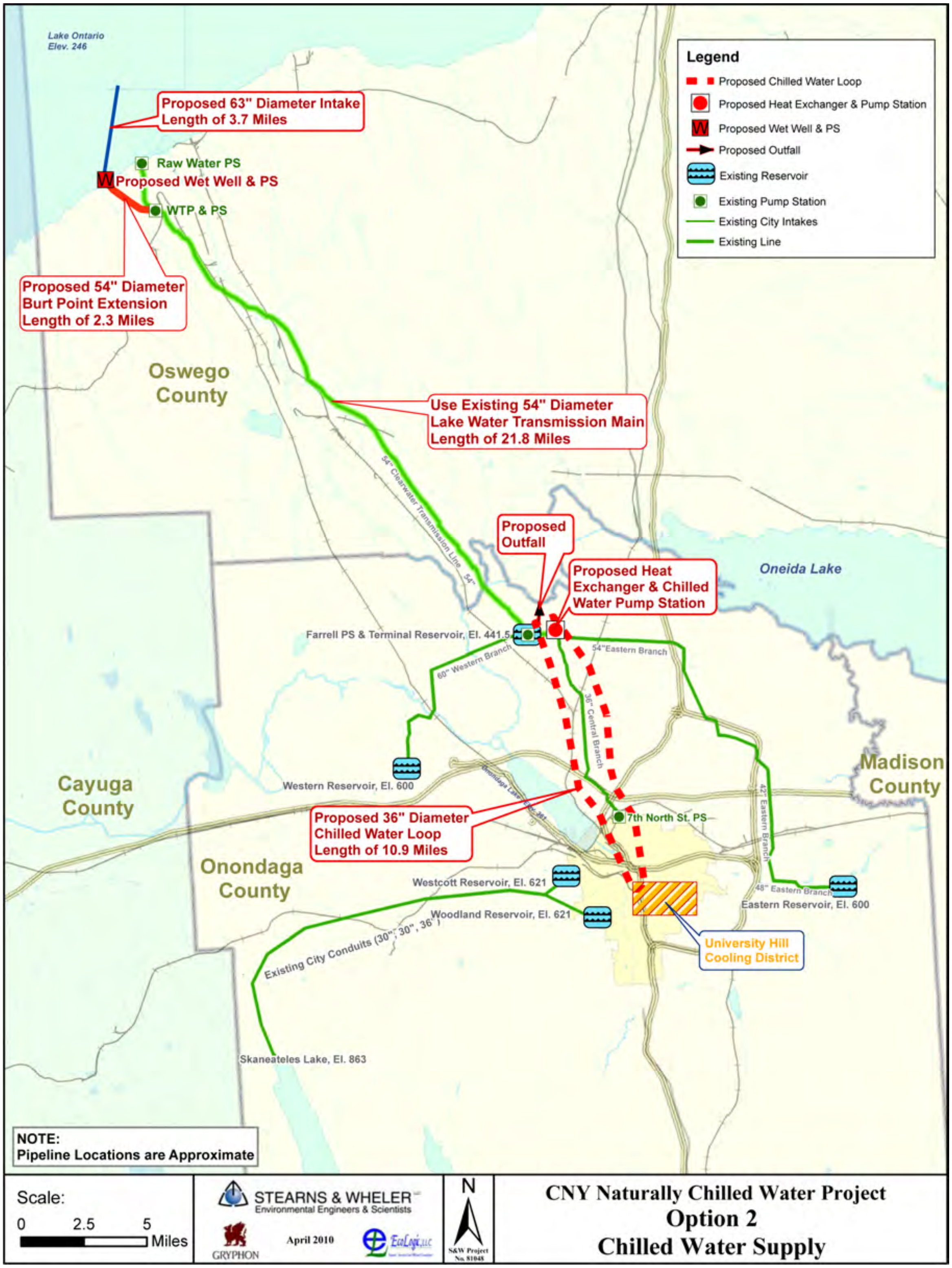


Figure 2-9. Schematic of Naturally Chilled Water - Option 3

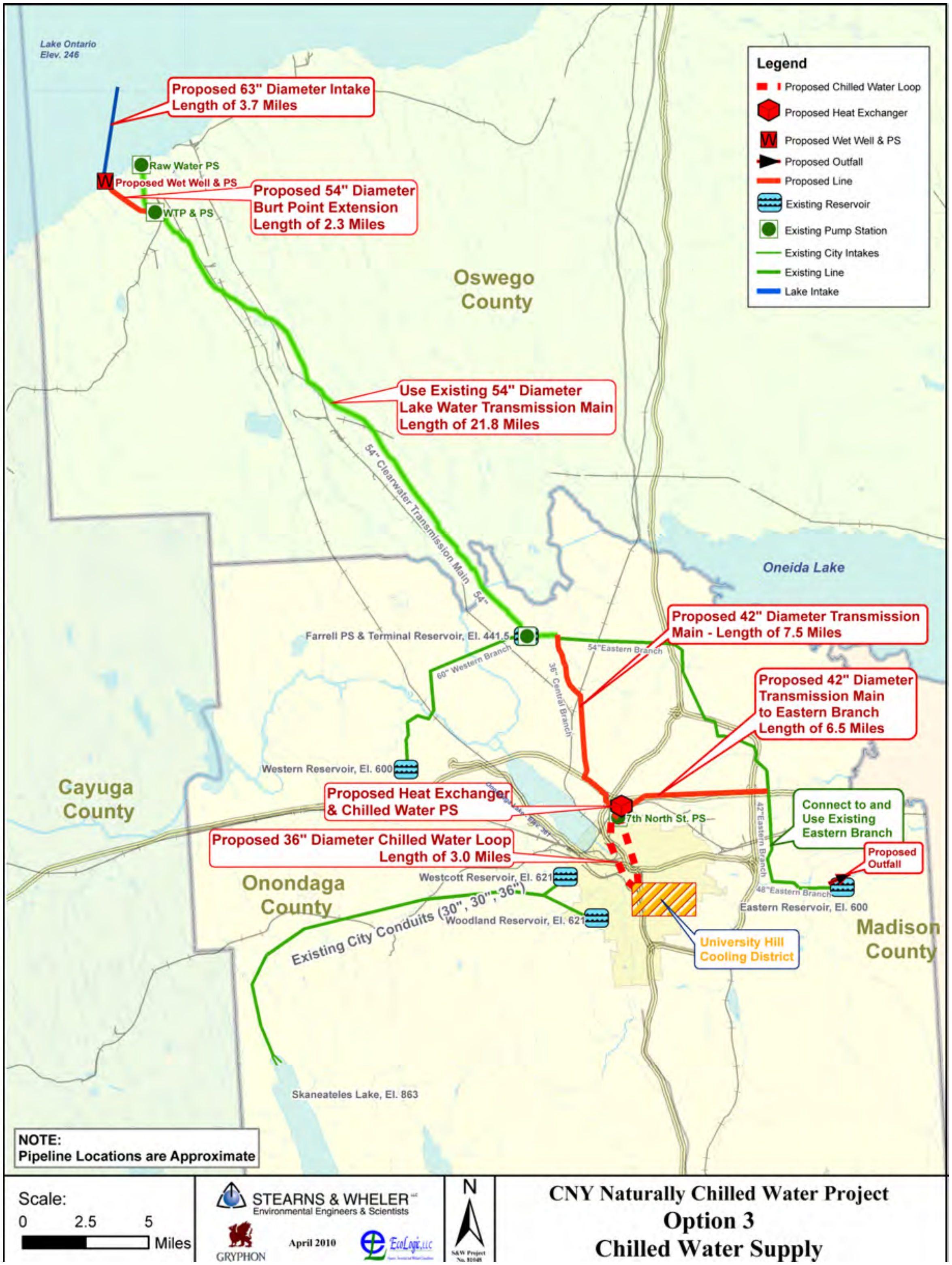


Figure 2-10. Schematic of Naturally Chilled Water - Option 4

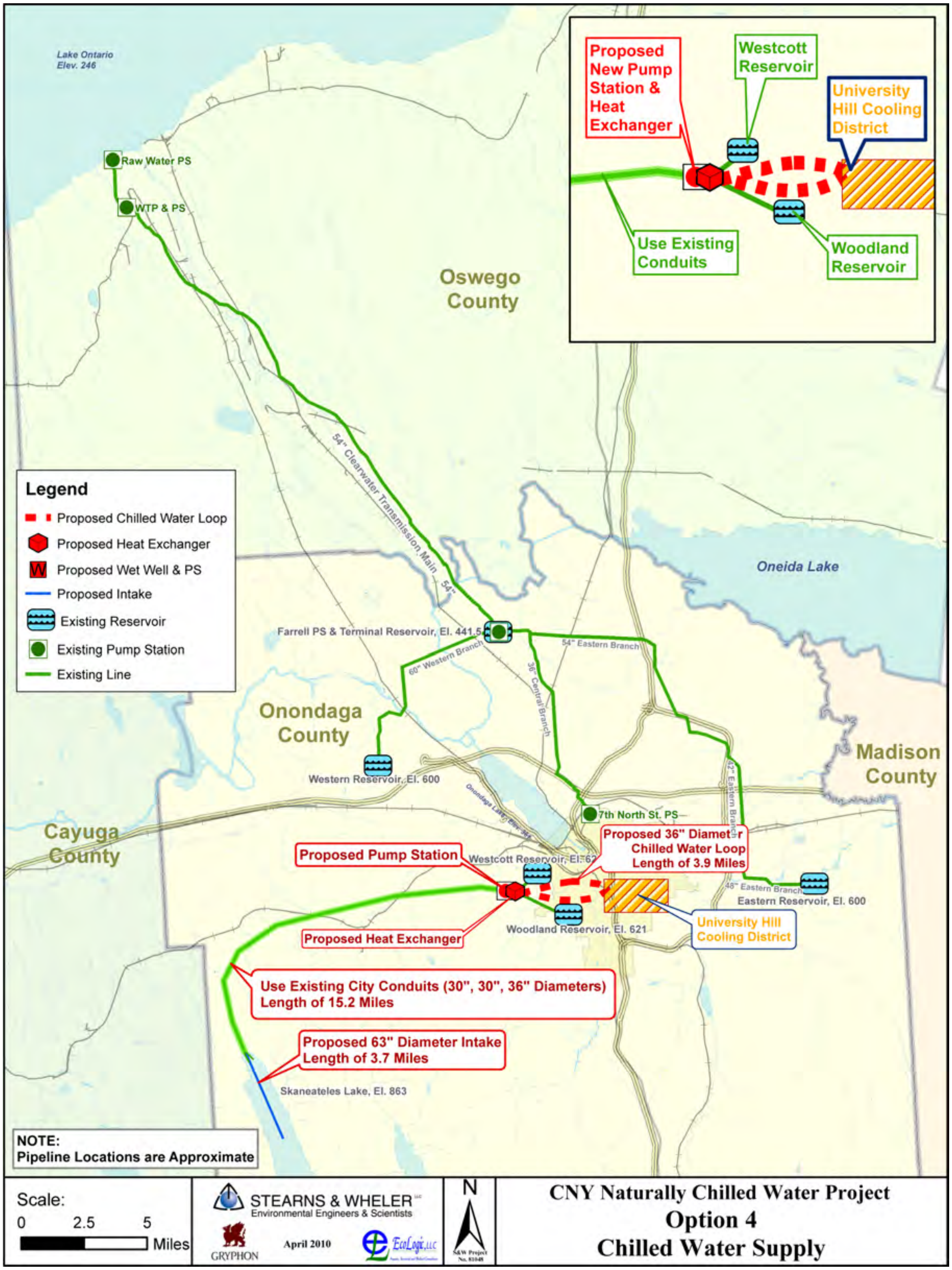
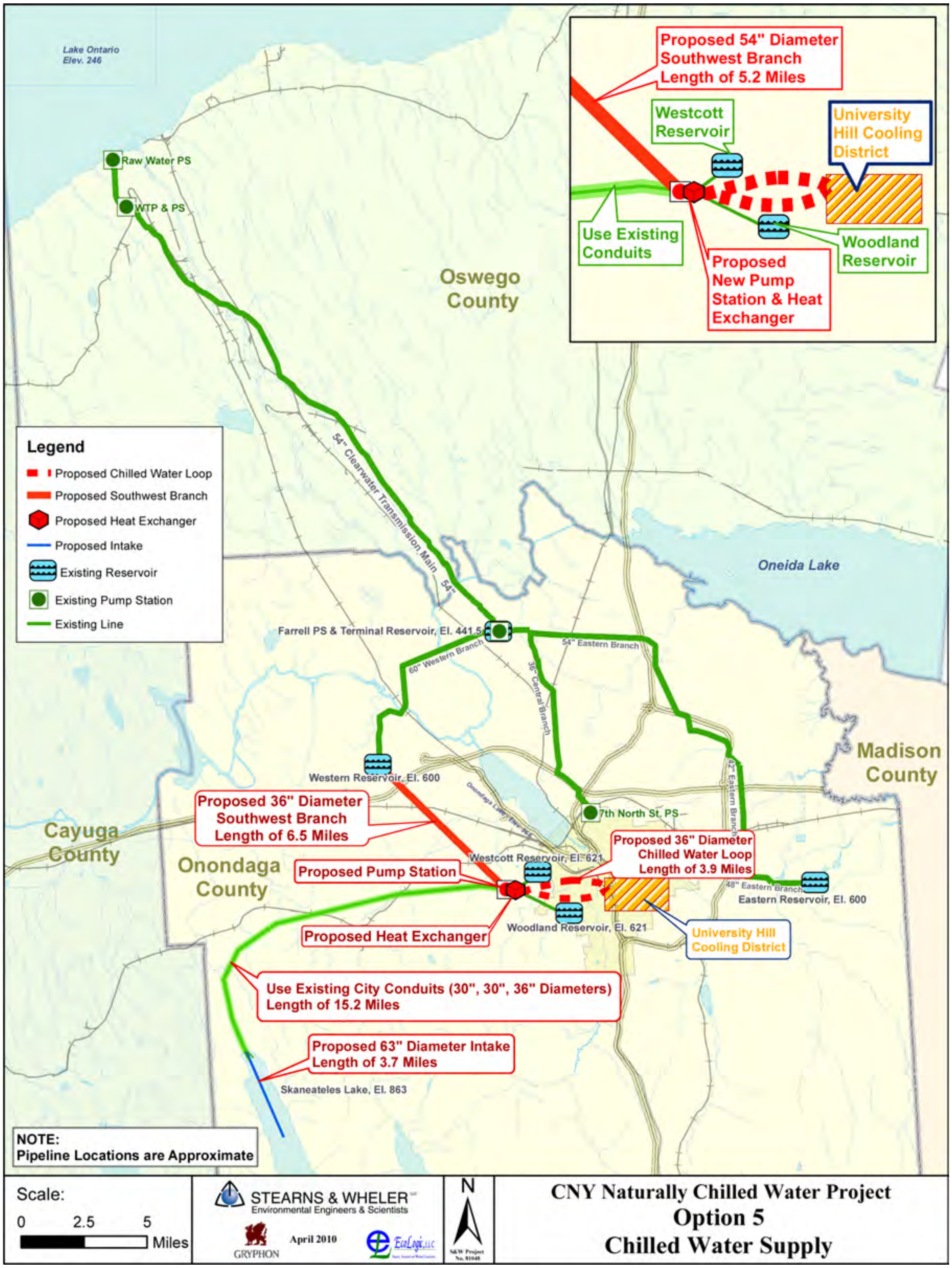


Figure 2-11. Schematic of Naturally Chilled Water - Option 5



2.7 Technical Evaluation of Options 1 - 5

The project team conducted a preliminary evaluation of the technical features of Options 1 - 5, and concluded there were no technical obstacles that would remove any of the five options from further consideration (see Section 14). The projects consist of proven technologies employed by both the Cornell and Toronto NCW systems. While construction of some system components would be challenging (e.g., intake pipeline), the experience gained from the Cornell and Toronto systems would provide important guidance if the project moves forward.

2.8 Ecological Evaluation of Options 1 - 5

The project team reviewed the five options with respect to ecological concerns, including intake design to prevent entrainment and impingement of aquatic species likely to be found at the intake depth, and risk of spread of invasive and exotic species from Lake Ontario to receiving waters (see Sections 12 and 19 through 22).

2.8.1 Source Water Considerations - Lake Ontario

Lake Ontario is an important source of high quality potable water. However, the fact that it is the lowest elevation of the five Great Lakes and a major international shipping route makes it susceptible to the introduction of exotic species. The presence of exotic species, and the risk for further introductions, pose important requirements on a Lake Ontario source of naturally chilled water.

A standard intake design, similar to both the Cornell and Toronto intake structures, will minimize entrapment and impingement of aquatic species. For Option 1, the intake water would have to be treated on-shore with disinfectant to reduce the risk of transport of exotic species. In Options 2 and 3, the intake water is treated at a potable water treatment plant, and no treatment beyond that would be required.

2.8.2 Source Water Considerations - Skaneateles Lake

Use of standard best available control technology in the intake design, consistent with the Cornell and Toronto projects, will serve to minimize entrainment and impingement of aquatic biota. While invasive species are always a concern, the design and construction of the NCW system do not provide a path for the introduction of any exotic species into Skaneateles Lake.

A deep water intake in Skaneateles Lake would provide one important benefit. Deep water is less turbid than water taken from shallower depths. A deep water intake would provide a direct benefit to the City of Syracuse in its continuing efforts to maintain the high quality of its potable water supply. This would be important in maintaining its filtration avoidance status, and thus help avoid the cost of a water filtration plant.

2.8.3 Receiving Waters

The original project concept (Option 1) included discharge of spent cooling water from Lake Ontario into Onondaga Lake. It was thought that the introduction would have beneficial effects on Onondaga Lake, in terms of temperature, levels of dissolved oxygen, and nutrients.

A rigorous review, including the use of a hydrodynamic model, showed only modest benefits for an Onondaga Lake discharge. This is because the water quality in Onondaga Lake has shown remarkable improvement in recent years in response to treatment improvements and upgrades for wastewater entering the lake (see Section 21).

For Options 2 - 5, discharge would occur only if cooling water requirements exceeded potable water requirements. These discharges would be infrequent, and consist of discharge of modest flows of drinking water quality, and of no anticipated adverse environmental effects.

2.9 Cost Estimates for Options 1 - 5

2.9.1 Methods Used

Costs estimates for a complex project can be presented in several ways. We use three methods in this report.

- Total Project Cost. This term is used to convey the sum of the construction cost estimates for all project components for an option.
- Annualized Project Cost. This term represents annual payments required to retire bonds used to fund the initial construction costs of a project. We assumed bonds would be available for a 30 year period, at

3% interest. Clearly, annualized project costs are directly proportional to total project costs.

- Operations and Maintenance (O&M) Costs. We calculated annual costs of electricity usage at $0.12 per kilowatt-hour (kWh). We added reasonable estimates for labor and other recurring costs.

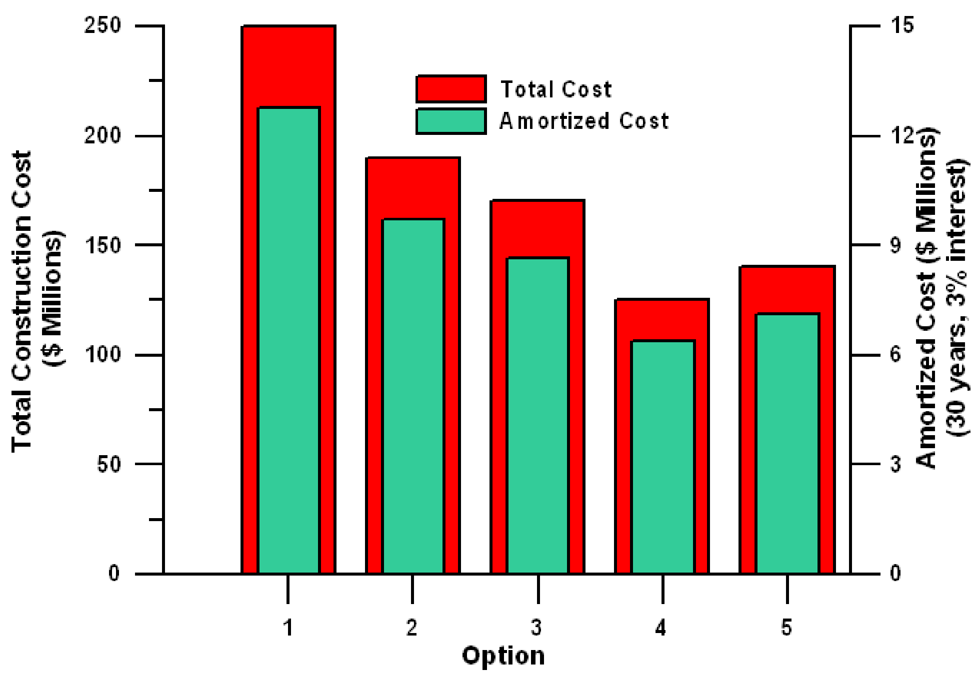
The annualized project cost and O&M costs can be presented as unit costs. We assumed each option would deliver 24.5 million tons of cooling per year (a reasonable assumption given a flow of 30 mgd and the temperature available from both source lakes). The unit cost is therefore the annualized project cost, the annual O&M cost, or their sum, divided by tons of cooling delivered per year, expressed as $/ton delivered.

2.9.2 Total Project Cost

The preliminary total project cost estimates are based on experience with the Toronto and Cornell chilled water projects, actual 2009 bid results from a large force main project in central New York, published estimating guides, and professional judgement. All values are in 2009 dollars (see Section 15).

The total and annualized project costs are shown in Figure 2-12.

Figure 2-12. Total Project and Amortized Construction Costs for NCW Options 1-5



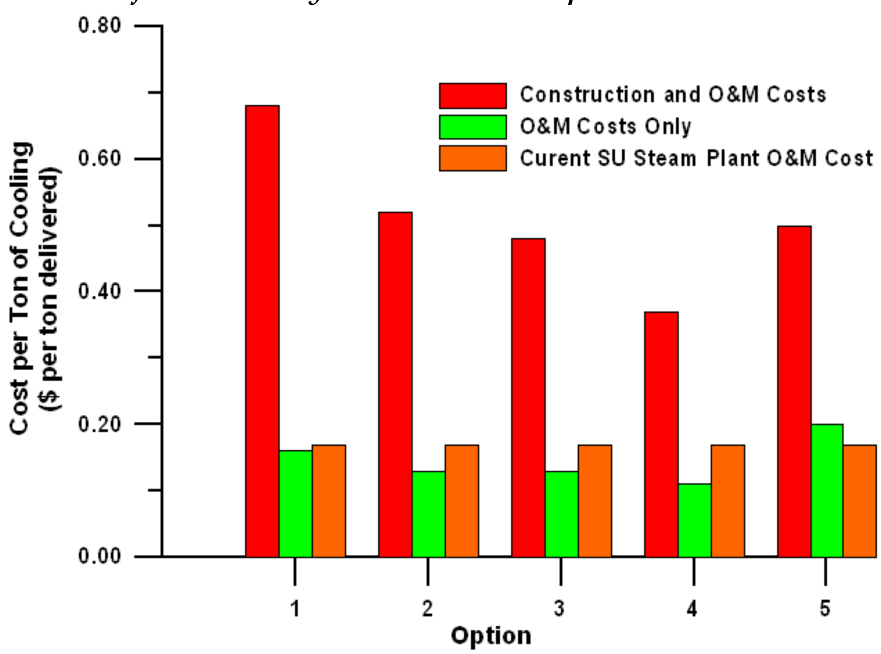
Option 1 represents the highest construction cost at $250,000,000, while Option 4 represents the lowest construction cost, at $125,000,000. This is not surprising given that Option 1 utilizes new infrastructure for the entire system, while Option 4 utilizes existing infrastructure to a much greater extent.

2.9.3 Unit Costs

Unit costs were calculated from annualized capital and O&M costs by assuming each option delivered 24.5 million tons of cooling per year[1]. Unit costs are presented in Figure 2-13, and compared to the current unit O&M cost of the Syracuse University mechanical chiller plant, adjusted to an annual output of 24.5 million tons of cooling.

It would be misleading to compare the NCW capital costs to the Syracuse University mechanical chiller capital costs. The Syracuse University capital costs include only the costs needed to replace the current mechanical chillers, while the NCW capital costs include all components of the project, e.g., intake structures, pump stations, heat exchangers, etc.

Figure 2-13. Unit Costs for Naturally Chilled Water Options 1-5.



1. This assumes 100% capacity. See Section 16 for a more thorough discussion of operating costs.

The O&M unit costs for Options 1 - 5 are competitive with the current unit costs of mechanical chillers, with Option 4 providing the lowest unit cost.

2.9.4 Sensitivity Analysis

The project team conducted a sensitivity analysis that examined units costs for Options 1 - 5 as a function of cost of electricity, value of offset greenhouse gas emissions, and consequences of federal and local grants to help offset construction costs (see Section 18).

The sensitivity analysis indicated that the unit costs of NCW Options 1-5 are affected by federal grants or tax credits or the local financial support of the regional water authority, moderately effected by fluctuations in costs of electricity, and much less sensitive to the value of greenhouse gas emissions reductions that might yield income from the marketing of carbon credits or certificates.

2.10 Other Benefits

2.10.1 Consistent Intake Water Quality

Options 2 - 5 use a deep water intake as a source of potable water. The deep intake will provide water of higher and more consistent quality than water withdrawn from a shallower depth. This is because lake water at shallow depths responds to algal blooms, runoff events, etc. These temporary disturbances are observed in shallower water and not at the proposed intake depths.

Options 2 and 3 use deep (250 ft, 76 m) Lake Ontario water as source water for an existing potable water treatment plant. In this case, the consistent intake water quality would provide a modest benefit in terms of consistency of plant operations.

Options 4 and 5 propose deep (135 ft, 41 m) Skaneateles Lake as source water. The deeper waters can be expected to be less turbid than water taken from the current intake depth of about 20 feet (6 meters). This represents an important benefit in maintaining the extremely high quality of this potable water source, and could help maintain the Filtration Avoidance Determination and thus obviate the cost of a water treatment plant for this important source of potable water.

2.10.2 Relationship to Sustainability Initiatives

Both Onondaga County and the City of Syracuse have sustainability initiatives in place. It is not clear how an NCW project would relate to those iitiatives. A NCW project could be an important component of these on-going initiatives.

2.11 Regulatory Concerns

The New York State Department of Health (NYSDOH) regulates potable water systems within the state. The current regulations, specifically Section 8.10.2 of Recommended Standards for Waterworks, prohibit the use of potable water in a heat exchanger.

Preliminary discussions with NYSDOH indicate that the agency is willing to consider the possibility of allowing water which has passed through a heat exchanger to be returned to the potable water system if the water is protected by multiple barriers. This item would need further study before the project was advanced to a design stage.

2.12 Institutional Arrangements

The project team reviewed the administrative structure for existing and proposed cooling (and heating) districts. Four administrative models were identified. They include: (1) privatization of chilled water districts; (2) establishment of not-for-profit cooperatives by governmental and private entities to manage a chilled water district; (3) employing private management schemes for all or part of a chilled water district and (4) establishment of a for-profit corporation by a municipal entity (see Section 25).

2.12.1 Privatization

A district heating system in Trenton, New Jersey ia an example of a private entity providing service to an urban area. The Cogeneration Development Company of New York City was formed and is absorbing constructions costs in anticipation of generating revenue by sales of heat to downtown buildings.

2.12.2 Not-for-Profit Cooperatives

The largest hot water district heating system in North America currently resides in St. Paul, Minnesota and is owned and serviced by a not-for-profit corporation called District Energy. It is governed by a board of directors comprised of three City-appointed members, three customer-elected members and a seventh member chosen by the other six.

2.12.3 Use of Private Management

Under this model, the municipality continues to own the system and remains responsible for maintenance, improvements and upgrades depending on its contractual agreement with the private entity, but the day to day management and service is performed by a third party. We found no specific examples of this ownership/management model.

2.12.4 Municipal Establishment of a For-Profit Corporation

A fourth model is a municipality's participation in a for-profit venture with other private entities. For example, the City of Toronto originally sought to create a district cooling system under a not-for-profit model. However, due to various constraints, it reorganized and established a for-profit entity.

2.13 Permits

A project of the magnitude and complexity will require permits and approvals from federal, state and local government agencies and departments. The permit requirements and government agencies responsible for issuing them are reviewed in Section 24.

2.14 Summary

Five options for a Central New York Naturally Chilled Water project are presented. Each option, in terms of unit cost per ton of cooling delivered, is competitive with, or cheaper than, current mechanical chiller installations.

The project team found no technical, ecological, or institutional issues that would prevent the implementation of any of the options.

3.0 Review of Two Naturally Chilled Water Systems

3.1 Section Introduction

In this section we review the history, conceptual basis, construction, and performance of two existing naturally chilled water systems: The Cornell University Lake Source Cooling Project and the Toronto Deep Lake Water Cooling System. We performed the review to inform our work in evaluating options for the Central New York Naturally Chilled Water Project.

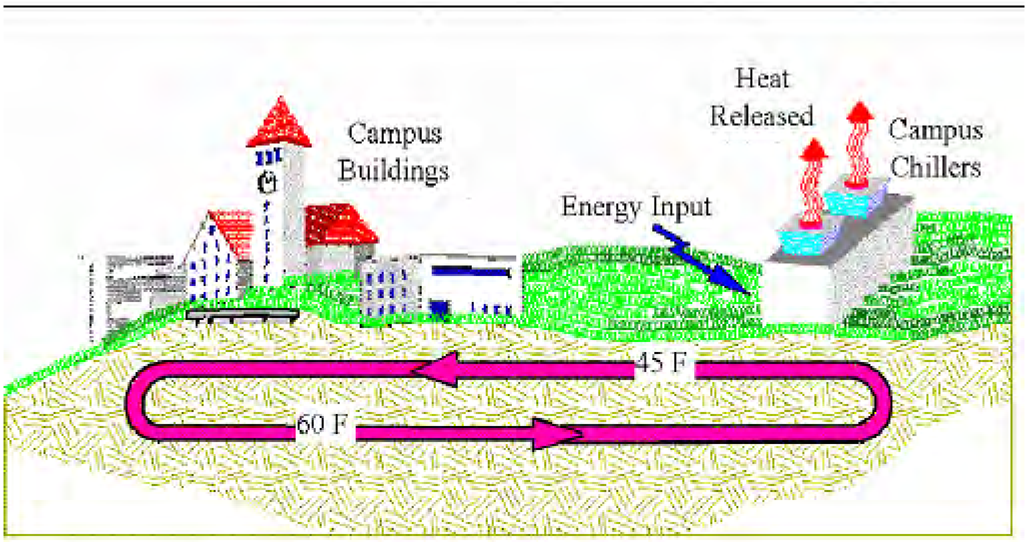
As will be seen below, the two existing systems differ in one fundamental regard: the Cornell system is completely separate from the local potable water supply, while the Toronto system utilizes a fraction of the naturally chilled potable water for cooling before distribution into the potable water distribution system.

3.2 Cornell University Lake Source Cooling

3.2.1 The Cornell Chilled Water System

The Cornell University chilled water system has been in operation since the early 1960's and by 1998 consisted of three chilled water plants with eight electric motor-driven chillers and a 4.4 million gallon thermal storage tank. All three plants pumped into a common underground piping network which consists of over 10 miles of underground direct buried piping with a volume of approximately 1.5 million gallons. Six of the existing chillers were of the hermetic type and two were of the open drive type, with the largest utilizing a variable speed drive. Included in the plants are other associated pumps, variable speed drives, controls, cooling towers and auxiliary equipment. The campus chilled water system (prior to Lake Source Cooling) is schematically represented in Figure 3-1.

Figure 3-1. Schematic of the Cornell University Chilled Water System prior to the Implementation of Lake Source Cooling (LSC)



The Cornell district cooling system operates year round, with summer chilled water supply and return temperatures at a maximum of 45ºF (7.2ºC) and 60ºF (16.2ºC). Winter chilled water supply and return temperatures are typically 40ºF (4.4 ºC) and 50ºF (10ºC). During the winter months, Cornell originally met cooling demand with free cooling from plate and frame heat exchangers using 38ºF (3.3ºC) water cooled naturally by outdoor air from either Beebe Lake water (from Fall Creek) or cooling tower water.

The chilled water system produces approximately 40 million ton-hours of cooling each year for research processes as well as for general air conditioning of laboratory space, computer rooms, lecture/teaching areas and common spaces. The system serves 75 buildings totaling over 5 million square feet of air conditioned space (about 40% of the core campus). The system delivers more than 18,000 tons of cooling capacity at peak demand, circulating water at about 30,000 gallons per minute (gpm). The original Cornell district cooling system was nationally recognized as one of the most efficient of its kind with an annual operating efficiency of 0.75 kWh/ton-hour versus 1.0 kWh/ton-hour for a typical district cooling system.

3.2.2 Lake Source Cooling (LSC)

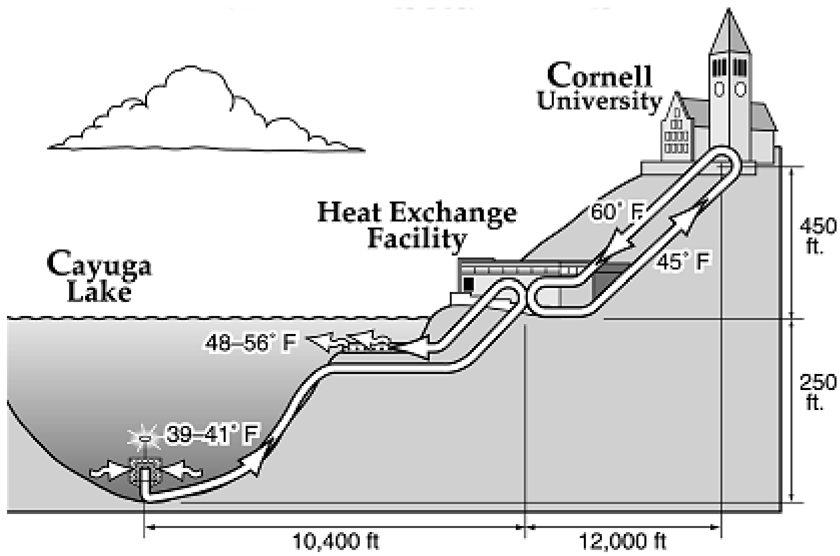
Four factors dictated a substantial change to the Cornell district cooling system in 1995:

1. compliance with federal laws that phased out chlorofluorocarbon containing refrigerants (CFCs);
2. replacement of aging equipment;
3. the addition of cooling capacity to meet growing loads; and
4. rising energy costs.

New cooling loads and renovation were expected to add 10,000 to 15,000 tons of cooling requirements over the next 35 years. Six of the original hermetic chillers could not be economically converted to non-CFC refrigerants. This would have required that the University replace six of its eight major chillers within a 10-year time frame, plus construct new chillers to meet increased demand. A significant capital outlay would be required by year 2010. The magnitude of these changes offered the University a unique opportunity to consider the development of Lake Source Cooling (LSC) as an alternative cooling source.

LSC provides a passive and technologically simple cooling option, utilizing a natural, non-polluting, and renewable resource. It uses the cold, deep water of Cayuga Lake to cool a closed loop extension of the present campus chilled water network without the need for mechanical refrigeration (all the heat added to the lake is released each winter). Electric power use has dropped to ~13% of that required by the original campus cooling system which represents a savings of over 25 million kilowatt hours on an annual basis. LSC came on line in July 2000 and has reduced both Cornell's reliance on refrigerants and electrical consumption thus reducing the pollutants produced in the generation of electricity by regional power plants. LSC also offers a 75- to 100-year system life, instead of the 30 to 40 years typical for chillers. A schematic representation of Lake Source Cooling is shown in Figure 3-2.

Figure 3-2. Schematic of Cornell University Chilled Water System Showing Relationship of the Campus to the Source Body of Water



The Phase I Feasibility Investigation revealed that an optimized LSC plant (18,000 tons initial capacity, and up to 20,000 tons as campus return water temperature increases), in combination with non-CFC chillers, would be more economical to operate over a 30 year period than a system based exclusively on chillers. In this plan, LSC would be supplemented, at peak loads, by existing equipment - the thermal storage tank and two open-drive HFC (Hydrofluorocarbon) refrigerant chillers. The other six hermetic CFC (chlorofluorocarbon) chillers are decommissioned. The LSC plant provides nearly all central cooling, capturing the majority of the energy savings, while the system's two remaining chillers are relegated to back-up and peaking service. The Phase I Feasibility Investigation demonstrated that LSC represented an economic and environmentally sound alternative for cooling the campus.

Once the feasibility of LSC was determined, the project proceeded into Phase II Schematic Design and Permitting. Phase II consisted of engineering schematic design development, Environmental Impact Statement (EIS) preparation, and filing of the associated regulatory permits. Environmental findings revealed no significant adverse environmental impact to the lake, verifying earlier findings that there will be no harm to the lake from construction or operation of LSC. The Environmental Impact Statement was accepted as final by the New York State Department of Environmental Conservation (NYSDEC) in December 1997 and in January 1998, the key NYSDEC permits were issued. Upon receipt of this key approval and agreements with the local municipalities and private landowners, the Cornell Board of Trustees approved funding for Phase III Final Design and Construction in January 1998.

Construction began in spring of 1999, with start-up and commissioning occurring during the summer of 2000. Though it required more initial investment than replacing the current system with standard technology, LSC is saving money over time by using a fraction of the energy needed with conventional electric-powered chillers and by reducing Cornell's future capital and maintenance expenses for chillers. As we move into the 21st Century, our society must find creative ways to reduce our impact on the environment. LSC provided a significant step in the right direction by providing the following benefits:

- Reduction of electricity use by over 20 million kWh/yr, equivalent to electrical use in 2,500 homes annually.
- Reduction of carbon dioxide emissions by over 56 million pounds per year.
- Reduction of sulfur dioxide emissions by over 645 thousand pounds per year.
- Reduction of nitrogen oxides emissions by over 55 thousand pounds per year.
- Elimination of the burning of over 19 million pounds of coal annually in regional power plants along with the associated impacts of mining, transportation and ash removal.
- Elimination of 40 thousand pounds of CFCs which are known to deplete the ozone and act as a greenhouse gas.
- Reduced reliance on HFCs which are known greenhouse gases and potentially have unknown environmental impacts.

3.2.3 LSC - System Description

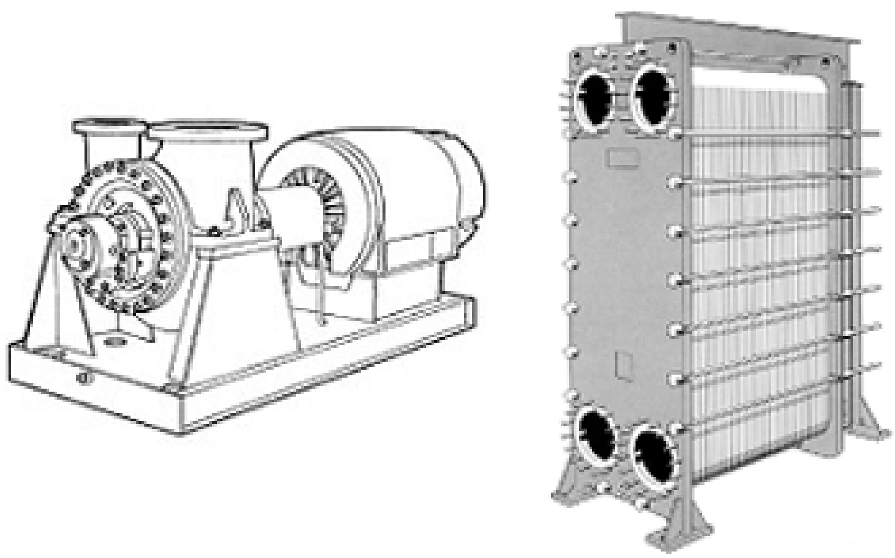
The chilled water lines that connect LSC to the campus distribution system are 100% welded, 42 inch API5L Gr X65 steel. The 12,000+ trench feet of supply and return piping was backfilled using controlled density fill and is protected from exterior corrosion using a combination of a three-layer epoxy and polyethylene coating plus a sacrificial anode type cathodic protection system. The transmission piping increased the system volume by 1.7 million gallons of water. Motorized isolation valves are located at the entry/exit point of the chilled water piping within the plant (see Figure 3-3), which allows the operator to easily secure the transmission piping in the event of a leak within the plant. Motorized isolation valves have also been installed in a vault where the transmission piping meets the existing distribution network, which allows the operator to secure the transmission piping in the event of a system leak. The chilled water transmission piping passes through a concrete anchor block at the building wall, which is designed to isolate the forces acting on the pipeline outside the facility from equipment inside the facility.

Figure 3-3. Image of Building Housing Staff, Heat Exchangers, Pumps and Control Equipment for the Cornell Lake Source Cooling System

The chilled water system is a "closed" loop; therefore, the distribution pumps provide no static head to "lift" the water to campus. Only the internal pipe friction due to flow dictates the pumping energy required at the plant. These pumps are used to circulate the closed loop water from the campus, through the plate and frame heat exchangers and then back to campus. The pump type is a between-the-bearings, radially split, double suction, dual volute designed and built to API Standard 610. There are five chilled water distribution pumps (Figure 3-4) in parallel with a design point of 6,600 gpm at 280 feet of head. The pump speed is 1800 rpm with 600 installed horsepower each. The pump outputs are controlled via variable frequency drives. The speed is controlled automatically based on system differential pressure on campus.

The heat exchangers (Figure 3-4) are piped in a parallel arrangement allowing any combination of pumps and heat exchangers to be on line to meet the system requirements. Each has motorized valves on the lake and chilled water piping, which allows the control system to automatically add or remove units from the process as needed. There are seven units installed with a total effective surface area of ~102,000 ft^2 (~9,500 m^2). The seventh unit was added to compensate for fouling of all the units and also adds redundancy to the system. Each unit is 100% full of plates (665), which are "hard angle" chevron design. The design duty is approximately 36,000,000 BTU/hr (3,000 tons) at 4600 gpm and a ΔT of 16^{o} F (8.9ºC) per unit. This is done using a LMTD of 2.6^{o}F (1.4ºC) and pressure drop of 16 psi.

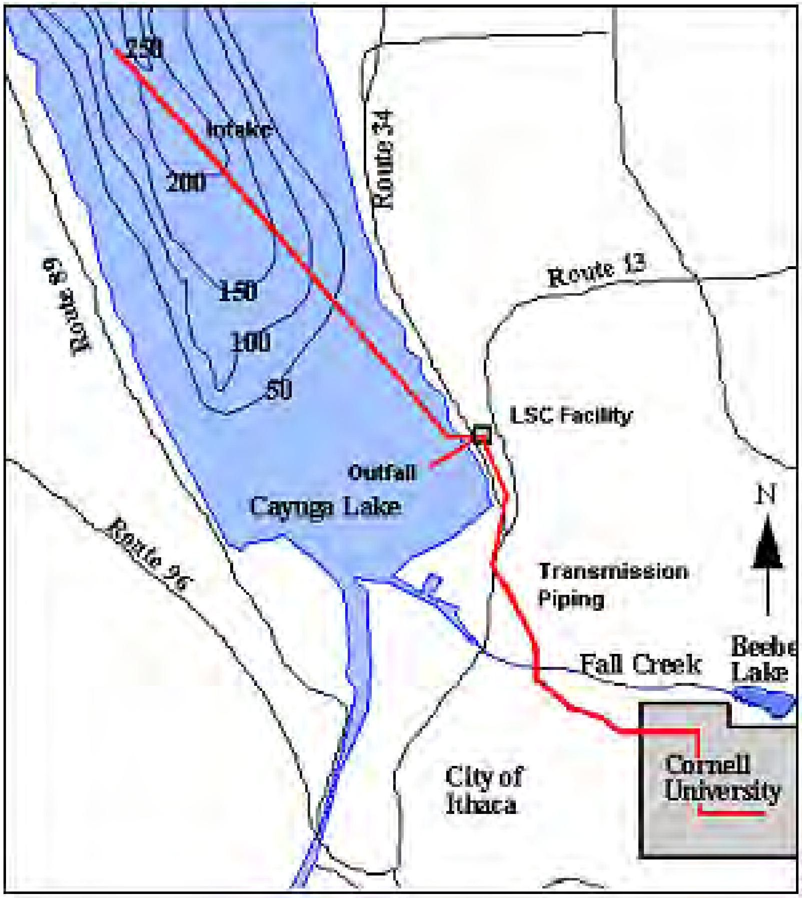
Figure 3-4. Schematics of Centrifugal Pump (left) and Heat Exchanger (right) as used in the Cornell Lake Source Cooling System



Lake water enters the system via a screened intake structure 10,400 feet (3,17 km) away in 250 feet (76 m) of water. The intake pipeline is 63-inch high density polyethylene (HDPE) that was deployed from the surface using a "controlled" sink process where water was pumped in at the shallow end and air was released at the other end. A series of stiffener rings and concrete collars keep the pipeline on the lake floor and protect it from mechanical forces. The outfall is 48-inch HDPE and is approximately 750 feet (230 m) long. The last 100 feet (33 m) of the outfall has 38, 6-inch nozzles about 1 foot above the bottom of the lake floor in 14 feet (4.3 m) of water, pointed up at a 20-degree angle and pointed north only. This configuration helps promote mixing of the return water into the receiving water.

The intake and outfall pass under a state highway and railroad before entering the facility. Seventy-two-inch steel casing pipes were drilled through rock and grouted in place. The 63-inch intake and 48-inch outfall HDPE pipe is installed inside the casing pipes and the annulus is filled with grout. Inside the plant, the casing/HDPE pipe adapts to steel intake and outfall piping. In addition, 63- and 48-inch stainless steel slide gate valves isolate the plant from the lake when necessary. Pipeline routing is shown in Figure 3-5.

Figure 3-5. Map Indicating Approximate Location of Piping in the Cornell Lake Source Cooling Project



The lake water enters the plant in a 22-foot wide, 39-foot long, and 28-foot deep (6.7 x 11.9 x 8.5 m) wet well. A turned down elbow is installed inside the wet well because the floor is ~15 feet below the pipe invert. The wet well is designed to hydraulically separate the plant piping from the lake intake pipe and protect it from under-pressurization should an inordinate pressure drop develop. This arrangement allows water to flow through the intake to the plant by gravity. At no flow, the water levels in the wet well and at the lake are equal. As water starts to flow through the plant, the wet well level drops below lake level and the resulting difference in hydraulic elevation allows the lake water to flow into the wet well by gravity. This level difference is also the exact pressure drop of the intake pipeline. Two level transmitters monitor this pressure drop and help track fouling of the intake should that occur. The system is also designed to reverse the lake water flow and allow mechanical "pigging" of both pipelines. This would be used to remove an infestation of zebra and/or quagga mussels should it occur.

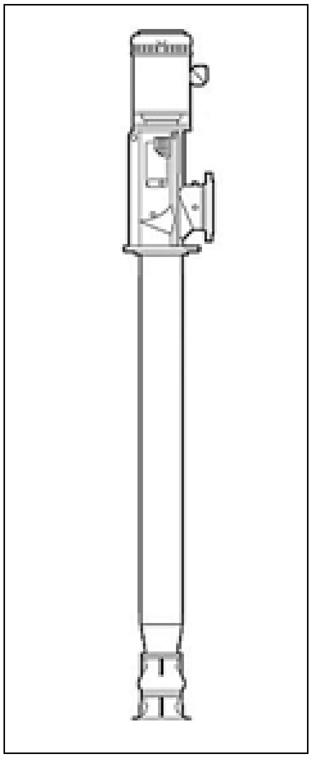


Figure 3-6. Image of Vertical Line Shaft Pump

The lake water pump type is vertical turbine, self lubricated, enclosed impeller, open lineshaft design. These pumps are used to circulate untreated lake water from the wet well, through the plate and frame heat exchangers and back to the lake. The pumps are mounted on a concrete slab, which spans the wet well. The pump column is approximately 30 feet long. The impellers sit near the bottom of the wet well and are connected to the driver via a shaft, which extends the length of the pump column. There are three lake water distribution pumps (Figure 3-6) with a design point of 13,000 gpm at 80 feet of head. The pump speed is 1200 rpm with 350 installed horsepower each. The pump outputs are controlled via variable frequency drives. The speed is controlled automatically based on the amount of heat exchangers in operation.

The lake water system is designed as a "siphonic" system. In this type of system, the only pumping power required is to overcome friction even though there is a significant elevation rise to the top of the piping system from the wet well supply. Essentially, as the water "falls" back to the lake in the return piping, it creates a vacuum, which in turn pulls water up into the system through the supply piping. The siphonic principle holds true provided the piping system stays full of liquid, flows full and remains free of vapor or air. This necessitates the need for an air extraction system (Figure 3-7), which maintains a full pipe. This system provides the initial system prime and then extracts air gasses that come out of solution. Because the lake water is an open body of water, it is essentially saturated with dissolved gasses. When this water is subjected to pressures below atmospheric (vacuum), the solubility decreases and gasses come out of solution. The increase in lake water temperature as it passes through the heat exchangers creates a similar decrease in solubility generating additional gas releases. A level switch monitors water level in the pipe system, which opens or closes a control valve connected to a vacuum tank. The vacuum within the tank is maintained using liquid ring vacuum pumps.

Figure 2-7. Air Extraction System at Cornell Lake Source Cooling plant intake

The lake water system includes biomonitoring. Many times each year the facility must conduct a biomonitoring run in compliance with the New York State operating permit. This automated system circulates 1% of the total lake water flow through a very fine plankton net. The contents are preserved and sent to a laboratory for classification and counting. The results are used to analytically determine entrainment of biological organisms. Entrainment is minimized using a screened intake. Fishes are prevented from entering the facility via a 2 mm gap wedgewire screen that envelops the intake structure.

3.2.4 LSC - Electrical

Electrical power for the LSC plant is obtained via a single 34.5 kv connection from the local utility provider. Incoming power is then split to parallel 2500 kva transformers at an incoming gang operated load interrupting switch. Two air cooled, mineral oil immersed transformers provide 480 VAC service to the facility in a high resistance, neutral grounded wye configuration. Two separate 480 VAC busses service the facility and are connected to the transformers via a rigid bus. The busses are installed in a common enclosure with a tie-break switch should a transformer be out of service. The motor control center has a double ended connection to either primary busways.

The chilled water pumps are driven using a 12 pulse full-wave diode bridge pulse width modulated (PWM), variable speed drive with DC-Link filtering and choke. The inverter section utilizes Insulated Gate Bipolar Transistors (IGBT) to produce a three-phase sine coded PWM output wave form. Bypass starters are not included. Each has a phase shifting input transformer that is required for the 12-pulse drive front end. The lake water pumps are driven with the same type of drives except they utilize a 6 pulse front end.

The facility is essentially unstaffed and the process is totally automated. The process control system is a programmable logic controller (PLC) (Figure 3-8) with redundant hot-backup processors. Direct Modbus+ and ethernet interfaces are used. The operator interfaces (Figure 3-8) are personal computers (PCs). These communicate with the PLC, Central Heating Plant (CHP) and existing chilled water plant control systems via dedicated Ethernet. The process is monitored by the utilities system operators on a 24-hour basis from a location approximately 3 miles from the LSC Facility. These operators are alerted to possible trouble using predetermined alarm limits in the system and can exercise full manual control via the operator interfaces. A dedicated fiber optic link connects the Lake Source Cooling facility with the CHP.

Figure 3-8. Images Showing Cabinets Containing Programmable Logic Controllers (left) and Operators' Computer Interface (right)

3.2.5 LSC - Control System

The control system utilizes one of five selectable locations on campus for the pump speed process variable. A remote terminal unit (RTU) sends the differential pressure reading (between supply and return piping) to the control system. A master station uses the operator selected differential pressure location as the process variable and modulates the pump speeds to maintain the process variable at the set point. If the differential increases, the chilled water pump speed will decrease and if the differential decreases, the pump speed will increase. The chilled water pumps are sequenced on and off automatically by the control system depending on total system chilled water flow.

The heat exchangers are also sequenced on and off automatically by the control system depending on total system chilled water flow. Any time a heat exchanger comes on line, the lake water pumps automatically ramp up to meet an operator selectable lake water flow rate per heat exchanger. This is done to maintain a minimum velocity of lake water through the heat exchanger plates which in turn minimizes the propensity to foul. The control system determines the set point for total lake water flow by multiplying the number of heat exchangers on line times the target flow per heat exchanger as input by the operator. Should the leaving chilled water temperature exceed an operator determined setpoint, the lake water system will automatically switch to temperature control mode and ramp the pump speed up to maintain the leaving chilled water temperature. Should the leaving chilled water temperature go below the setpoint, the lake water system will automatically switch back to flow control mode and maintain the minimum desired flow rate per heat exchanger.

A fully automated booster pump station was also employed to alleviate high differential pressures in the core campus distribution system. A 24-inch "spur" feeds a section of the campus that is on the fringe of the networked distribution piping. By adding a pump in series at the interconnection of this spur, the pumping energy needed at the LSC facility was greatly reduced, as was the capital cost associated with it. This booster pump station is installed in an underground vault including a variable speed drive and RTU. The control logic for this booster station resides in the PLC at the LSC facility (3 miles (4.8 km) away) and communicates via the dedicated fiber optic link.

Figure 3-9. Heat Exchangers and Chilled Water Pumps (left) and Wet Well and Lake Pumps (right) of the Cornell Lake Source Cooling Project.

3.2.6 LSC - Challenges in Permitting and Design

The challenges during permitting and design included a wide variety of environmental, community, regulatory, technical, and economic issues. By far the greatest challenge was the fact that there was no precedent for a complete deep water cooling system design. There were a number of systems around the world that had individual pieces similar to LSC, but none were nearly identical. The similar systems that preceded LSC included Purdy's Wharf in Halifax, Nova Scotia, Canada; the Stockholm Energie seawater based system in Stockholm, Sweden; and the Natural Energy Laboratory in Kona, Hawaii. All of these systems were based on seawater resources, and had very different intake characteristics, an element that was viewed as the highest risk to the project.

3.2.6.a Environmental

Environmental challenges during permitting were significant in that there was no precedent in the United States for a deep lake water intake utilized for non-contact cooling. There were many examples of shallow intakes (less than 100 feet (30.5 m) water depth), but none at 250 feet (76 m) Immediately upon investigation of the idea in early 1994, the project team decided to enlist the help of a Cornell Faculty Scientific Advisory Committee (FSAC) and an outside consultant, Stearns & Wheler L.L.C., Cazenovia, NY. These scientists determined that investigation was required into the impacts from construction, biological effects in the vicinity of the intake (entrainment and exotic mussels) and outfall (thermal and exotic mussels), and water chemistry changes and thermal impacts in the vicinity of the outfall.

Over the course of the first three years of project investigation (1994 through 1996), lake data were collected. The field effort, in excess of $700,000, was documented in a scientific report that was shared widely with the local community and the NYSDEC. Past data and studies complemented the new Cornell LSC work, and were referenced by the Environmental Impact Statement that was created and shared through the New York State Environmental Quality Review Act (SEQRA) process with NYSDEC as Lead Agency. The Final EIS included a statement indicating “no significant environmental impact” which allowed environmental and local permitting to be completed and the project to be constructed.

3.2.6.b Construction

All impacts from construction were characterized as short term and minor in nature. Near shore dredging was required to keep the top of the intake and outfall piping near shore below safe boating depth. The dredged materials were characterized and the Cornell FSAC recommended going beyond NYS-DEC dredging guidelines and removing the dredged materials from the lake. Their recommendation was adopted. Impacts from pipe laying operations on the lake were very limited (normal boats, tugs, barges, etc.). All equipment on the lake was required to use only vegetable oil based hydraulic fluids. This was a wise move as one hose burst event did occur. Near shore work was timed to avoid major spawning periods.

3.2.6.c Water Chemistry

Of the many water chemistry parameters studied and characterized, phosphorus was by far the largest concern. As the limiting nutrient in Cayuga Lake, phosphorus transport from the deep lake waters to the shallow waters and any impacts this would have quickly rose to the top of the list of concerns. A huge amount of effort and expense went into characterizing the phosphorus content of the deep lake waters and how it would differ from the shallow waters when the deep lake waters were discharged into the shallow photic zone at the southern head end waters of Cayuga Lake. The concern was whether the deep lake waters would create a noticeable change in the biological activity before being dispersed through mixing in the receiving waters and whether a noticeable change in algae concentration or quantity would occur.

The analysis of two full years of lake data showed that the deep lake waters had similar or lower phosphorus concentration than the receiving waters. Unlike shallow lakes with large nutrient input loads, Cayuga Lake's deep waters do not have a higher total phosphorus concentration than the shallow head end waters. The shallow southern head end waters are significantly affected by runoff and stream flows, area waste water treatment plants (+80% of total nutrient load during the study period), and wave re-suspension of shallow lake bottom clay sediments (that contain phosphorus). Only soluble reactive phosphorus was found to be higher than the receiving waters, but this subset of total phosphorus quickly turns into total phosphorus when it is converted into biological material by algae. Because the concentration of algae is determined by the total phosphorus, the deep lake water was characterized as not being able to create a higher concentration than the receiving waters. In fact, most of the time it would be less. To be conservative, the EIS assumed 100% soluble reactive phosphorus in the total phosphorus that all became algae. This still fell well below the natural variability in phosphorus in the southern shallow receiving waters.

A number of outfall alternatives were considered and analyzed in the EIS including a shore outfall (typical for a conventional power plant), a shallow outfall 500 feet (150 m) offshore in about 14 feet (4.2 m) of water depth, and an outfall on the "shelf" at a depth of about 100 feet (30.5 m) (out of the photic zone). A shallow depth outfall 500 feet off shore including a 100-foot long diffuser was chosen because it represented best engineering practice at a reasonable expense, and provided the best mixing and lowest overall impacts. Because the returned lake water phosphorus concentration (less than 20 micrograms per liter) and total load (less than a 2% change in the budget for the southern basin) fell well within the natural variability of the southern basin receiving waters, a deep 100-foot depth outfall alternative was rejected which eliminated a $2 million expense.

Another significant water parameter of concern was turbidity. It was not known until lake data was taken that the deep lake water is nearly at all times of higher clarity (i.e., lower turbidity) than the receiving southern basin waters. The turbidity in southern basin waters is highly influenced by stream runoff and wind events that cause wave re suspension of shallow lake bottom sediments. Wind events and storms will turn the first two miles of the lake brown, and long periods of turbidity occur due to these two major factors. Turbidity was found to be dominated by suspended sediments, not algae in the southern shallow waters. This was found to be different from the mid lake reference sites where turbidity was more useful as an indicator of productivity along with algae concentration. Only after very large storm events where it took a very long time for a slight change in turbidity to occur in the deep lake waters, would the returned lake water be near or slightly above the receiving waters. Generally, it was found the deep lake waters would be of lower turbidity than the receiving waters.

Even though an enormous amount of data, analysis, and outreach was used to illustrate the "cooler, cleaner, clearer" argument for why the outfall location would not cause any harm to Cayuga Lake, a number of local citizens were very concerned and some remain so today (2008). These citizens' concerns do not represent the consensus of the scientific community, that LSC's return waters should not cause any harm and that the correct outfall method/ location was chosen. As a result of the citizen concern, a very significant lake monitoring program was created as part of the New York State Pollutant Discharge Elimination System (SPDES) permit for LSC. This program continued largely unchanged through 2008, even though Cornell, the FSAC, the independent lake monitoring consultant Upstate Freshwater Institute (UFI), and more recently the Tompkins County Water Resources Council, have all recommended simplifying the program and focusing on a lake based community wide monitoring effort. The lake monitoring program will undoubtedly be a significant element of the SPDES renewal which began in 2008.

3.2.6.d Biological

Biological impacts included those that would occur from entrainment of organisms at the intake (fish, zooplankton, exotic mussels) and thermal impacts to fish at the outfall. Both of these were carefully studied and mitigation measures were included to reduce the impacts below a level of significance. The presence of and expected future significant growth of exotic freshwater mussels were a large element of the environmental investigation.

After meaningful discussion with the NYSDEC and a short-lived effort to utilize an ultrasonic fish deterrent, it was decided that the intake would include 2 millimeter gap wedgewire. Two species of concern were identified: alewife (an invasive herring species) and mysids (a small freshwater shrimp). Both are very important elements in the food chain and the NYSDEC did not want any significant mortality for either species. The wedgewire screen with a 3 inch/second velocity was designed to eliminate impingement and mortality for alewife and any other fish species.

Mysids were characterized as having a daily cycle in 250 feet (76 m) of water that included time in the vicinity of the intake and potential entrainment in the intake waters. A field test program determined that an open intake with the ultrasonic fish deterrent should include a low wattage light to deter the mysids from the vicinity of the intake. Even though the final intake included the 2 mm wedgewire, the mysid light was initially in place. This light was deployed before startup and lasted nearly five years on a trial basis before being lost during maintenance activities. It has since been abandoned and Cornell has recommended to the DEC that it not be continued due to the inherent difficulty of maintaining such a system at a depth of 250 feet (76 m) and the likelihood that the 2 mm wedgewire is best available control technology and is likely deterring mysid entrainment.

Exotic fresh water mussels are in Cayuga Lake and the project was designed to accommodate their growth and require periodic mechanical cleaning of the intake screen and the intake and outfall piping. A significant amount of effort went into investigating alternatives for deterring zebra and quagga mussels from attaching to the intake structure, the intake piping, the plant piping, and the outfall. In the end, it was decided that any of the then "approvable" methods would likely cause a significant issue with the local community or the FSAC. All of these were rejected for a plan that includes letting them infest the system, and periodically mechanically cleaning them. The intake is removable to the surface for cleaning with a shallow dive through an ingenious lifting and replacement scheme. The intake and outfall piping are "pigable" from shore with full reverse plant flow possible during pigging of the intake. The plant piping is cleanable by heating and mechanical removal with hand tools.

Impacts in the vicinity of the outfall were mainly characterized as thermal shock to fish species. The outfall was designed with a diffuser system to quickly disperse the returning lake water and mix it with the receiving waters. This rapid mixing makes sure that fish species can not be shocked and killed by the temperature difference between the returning and the receiving waters. In summer, the temperature is slightly colder than the receiving waters, in spring and fall the two waters are about the same temperature, and the returning lake water is slightly warmer in the winter. In all cases, the diffuser is able to mitigate any fish impacts. Infestation and mechanical cleaning of exotic mussels from the piping systems was characterized, and the amount of mussels involved was not adequate to cause any local water quality impacts.

3.2.6.e Thermal

Thermal impacts were initially the highest concern of community members and regulators. Once the very cool temperature of the returning deep lake water was understood (up to 57ºF (13.9ºC) in summer, about 46ºF (7.8ºC)in winter, with variation in between during spring and fall), and the scale of the heat input were understood, this issue quickly was reduced in importance.

In summer, the southern shallow receiving waters are often between 60ºF (15.6ºC) and 70ºF (21.4ºC), and the slightly cooler returning deep lake water is about 57ºF (13.9ºC). The slightly cooler water is quickly mixed to ambient by the diffuser mitigating any potential impacts to fish or algae productivity. In addition, seiche wave activity caused by winds on the lake, can cause very large changes in temperature in the southern basin as cold deep water ebbs into the southern basin when the warmer surface waters are blown north by strong southerly winds. In addition, the total heat input from LSC as characterized by the EIS was about two hours of additional sunlight over the course of a full year. The reality of operation is that the input is less than an hour of additional sunlight each year.

During winter, the southern shallow receiving waters are at 39ºF (3.9ºC)or below. The returned deep lake water is about 47ºF (7.8ºC) and the flow is one seventh of summer peak. This returning water is quickly diffused to the ambient temperature by the diffuser, and the reduced area of the plume does not create a "warm pool" of water that fish might stay within and be shocked by movement out into the colder ambient waters. Wind wave and currents also add to the mixing.

Spring and fall periods include a great deal of wind, wave, and weather induced mixing and temperature change. At this time, the returned deep lake water varies from 47º to 55ºF (7.8º to 12.8ºC) and quickly is mixed by the diffuser with the ambient waters.

At all times, the thermal impacts for LSC were analyzed by both local and lake wide thermal models. They were found to be well below the natural variability and were characterized as not to have a significant impact.

3.2.7 LSC - Planning Level Cost Estimate Assumptions

Cost estimating for the LSC project involved a combination of engineer's estimates, vendor quotes, contractor pricing, comparisons to other large piping projects, and peer review. Cost estimating, engineering modeling, and economic modeling were the foundation for decision making. The project is designed for a 100-year life minimum, recognizing that components such as electrical gear and rotating devices will require replacement at a 30- to 50-year interval.

The intake piping system was the most unusual and least known element of the system, and required a very specialized team of sub consultants to create a cost effective, reliable, nearly maintenance free, and constructible design. The single largest decision step made to enable the overall project was the choice of solid wall 63-inch HDPE intake pipe. This pipe size was the largest of its type in the world at the time, and it became the size limiting element of the project. It also allowed the project to happen because there was a very large step change in cost to go any larger due to the much higher cost of either steel or fiberglass reinforced plastic. Intake assumptions included:

- 63-inch outside diameter HDPE pipe material, solid wall.
- Two pipe sections: one for deep water (over 35 feet (10.7 m)); one for shallow water.

- Thermally fused subsections 1,200 to 1,500 feet (370 to 460 m) with flanged ends, total length 10,500 feet (3200 m).
- Hydrotest in the water by blanking off flanged ends of subsections.
- Custom designed stiffening rings made of concrete, concrete and epoxy coated ductile iron, and ductile iron moving from shallow to deep water.
- Controlled submergence from the surface with tension (static pull) to control the shape of the pipe to a minimum of 60 diameters bending.
- Remove rocks from the path and lay the pipe directly on the lake bottom, dredge near shore to keep the pipe top below safe boating depth.
- Sacrificial anodes attached to all ductile iron designed for 100-year life to protect ductile iron.
- Innovative intake structure design that included 2 mm wedgewire screen, ability to retrieve and replace the screen from the surface with only a shallow dive, and ability to pull the entire intake to the surface via a grapple line and replace it on the bottom with only a shallow water dive and Remotely Operated Vehicle supervision.

The outfall was modeled after typical outfalls used in waste water treatment plants. The outfall was designed as 48-inch HDPE pipe with nozzles to distribute the returning lake water and diffuse it quickly into the ambient waters. Outfall assumptions included:

- 48-inch outside diameter HDPE pipe material, solid wall.
- One pipe section, one assembled piece 700 feet (21.3 m) long.
- Hydrotest in the water by blanking off flanged ends.
- Custom designed concrete and ductile iron stiffening rings with four foot square steel plates that were driven through slots in the sides of the anchors to provide lateral support against wave action.
- Controlled submergence from the surface.
- Dredging for the entire length to keep the pipe top below safe boating depth.
- Sacrificial anodes attached to all ductile iron designed for 100-year life to protect the ductile iron and steel components.
- 38 nozzles, 6-inch diameter, over about 100 feet (30.5 m), pointed up slightly from horizontal for the outfall flow to promote mixing, PVC material.

- Blind flange on the end, turned up slightly, for use during pigging to allow the pig to exit on the outfall or allow water to come in during reverse flow for pigging the intake.

The heat exchange facility (HEF) is the part of the project that was the most conventional to construct. Nonetheless, it was a very difficult facility to design and construct because it is built into a hillside of rock and is substantially below grade, with the wet well and lake piping being significantly below lake level. HEF assumptions included:

- Reinforced concrete structure below grade, pinned into the rock.
- Steel structure above grade with pre cast concrete wall panels, PVC membrane roof.
- Intake and outfall piping were bored under the railroad (complicated and lengthy permitting process) and state highway into the wet well using 84-inch diameter bores, steel sleeves grouted in place, controlled flooding and installation underwater, and submerged grouting of the annular space.
- Chilled water piping enters/leaves through a 100 cubic yard anchor to lock the pipe at this location and prevent any force from the route being transmitted to the plant piping.
- Single drop with motor operated switches either side of line connection 34.5 kV electric service from the utility (double ended feed to this circuit by the utility).
- 2 x 80%, 34.5 kV x 480 V, 2500 kVA transformers with tie breaker on the 480 V switchboard.
- All variable speed pumping, no throttling at all for flow control (5 x 600 HP chilled water, 3 x 300 HP lake water pumps).
- API grade vertical split case double inlet steel centrifugal pumps due to the very high static head required, variable speed.
- Vertical turbine AWWA style lake water pumps, variable speed.
- 304 stainless steel plate-and-frame heat exchangers, 6 units full load, 1 extra unit for fouling, all seven in parallel with a min to max flow to control fouling and minimize pressure drop.
- Fully automated and unstaffed facility using industrial PLC-based controls and industrial/utility grade instrumentation, monitored from 3.5 miles away in the central utility control room in the Central Heating Plant, communications via dedicated fiber optic Ethernet.
- All isolation and control valves in the plant are high performance butterfly style valves with Limitorque electric gear motor driven actuators.

- Full plant HVAC to control the plant environment, use of the electric room waste heat in winter to heat the building.
- Many aesthetic elements are included on the building exterior, site retaining walls and landscaping to disguise the function of the building and make it visually pleasing in the lake shore environment.

The chilled water piping was the largest cost in the project, making up roughly half of the construction cost. During design the team chose coated API welded steel pipe over the other options available due to its much higher quality of construction and design life (life cycle cost). The chilled water and lake water piping are both designed to basically have an unlimited (100 year plus) life with minimal maintenance. Chilled water piping assumptions included:

- 42-inch API 5L double submerged arc welded steel pipe, 0.5-inch wall thickness, coated with a three-layer fusion bonded epoxy/polyethylene coating.
- Kanusa shrink sleeves at all weld joints.
- Polyken YGIII three layer tape wrapping at all fittings.
- Sacrifical anode cathodic protection, double strings at each station, designed for 100-year life and 0.5% coating holidays.
- 100% X-ray of all welds, weld survey.
- Pigging of the piping system after construction with air and foam pigs to remove all debris from the system before filling.
- Hydrotest to design of piping.
- Welded body ball valves for all vents and drains, two valves in series at every location due to the high static pressure.
- One drain manhole at the low point of the system, one tie-in manhole at the entry point to the looped campus chilled water distribution system with a cooldown manual bypass (to cool down the 4 miles (6.4 km) of chilled water pipe between the HEF and the campus), automated butterfly valves at this location and the main plant wall for isolation if a leak is detected.
- No vents or drains at any other location (water velocity removes air bubbles) and the pipe generally follows the contour of the ground.
- Free span across one gorge and under one highway bridge, supported through bridge abutments.
- 100% holiday coating testing before backfill.

- Controlled density fill in the pipe bedding zone (200 psi cement, sand and water), 18-inch gap between pipes, 13 foot (4 m) wide by 10 foot (3 m) deep ditch.
- 5 feet (1.5.m) depth of bury in streets, 3 feet (0.9 m) depth of bury off road, 4 feet (1.2 m) depth of bury on campus.
- Five major tie-in points with valves in manholes to tie into the campus looped chilled water distribution system.

3.2.8 LSC - Decision to Proceed and Cost Estimates

The cost estimate for the project and the future price of electricity were the largest drivers in whether to proceed at every decision step. Without a cost-effective path forward, the project would not have continued. The university makes all of its utility system decisions based on life cycle cost analysis and LSC was a significant challenge due to the unusual construction features which caused difficulty in estimating costs as well as the uncertainty raised by the ongoing deregulation of the New York electricity grid.

The cost estimating was always done as a combination of vendor equipment and materials quotes, engineer's estimates, and contractor paid estimates. At the last decision step a peer review estimate was done to get an even higher confidence in the ability of the university to build the project for what it was estimated to cost. Because of the cost of the environmental investigation and permitting, the engineering advanced to between schematic design and design development level detail at the final decision to proceed. Based on the design level the decision was made to carry a 20% contingency on construction going into the final approval.

3.2.9 LSC - Planning Level and Final Cost Estimate Comparison

Development of the project spanned early 1994 through final approval in early 1998. Over that time period the cost of the project changed from ~$50 million to ~$55 million. The change was attributable to further development of the design ($4 million) and a higher environmental investigation and permitting cost ($1 million). The higher environmental investigation and permitting cost was mostly due to the considerable level of effort taken to characterize the lake impacts, mitigation measures, and a very high level of scientific investigation and analysis to show that LSC could operate creating global environmental benefits without harm to Cayuga Lake.

Two significant changes were made during project finalization that contributed to the increased project cost. One was to construct all facilities on the opposite side of the highway from the shoreline. It was felt that any shoreline facilities would be very difficult to design aesthetically pleasing and represented too large a risk for permitting. Instead, a park for the Town of Ithaca was constructed over the area where the piping made landfall, creating a real and exceptional benefit for the public. The second was constructing the transmission piping 42-inch vs. 36-inch. This decision was made to reduce life cycle cost of the chilled water system by reducing pumping energy. The increased size lowered installed and operating horsepower for pumping, offsetting the higher cost over time for the larger pipe. Each of these changes had a value in the range of $1 million.

Table 3-1 summarizes the final approved estimates (spring 1998) and the actual final constructed project cost through close out in the fall of 2000. The project came on line in July 2000.

Table 3-1. Elements of Project Cost - Cornell Lake Source Cooling

Project Element	**Cost (Millions of dollars)**	
	1998 Cost Estimate	**Final Project Cost**
Engineering	5	6
Construction:		
Lake piping	7	8
Heat Exchange Facility	13	14
Chilled water piping	21	24
Construction (total)	41	46
Environmental	2	2
Owner costs	4	4
Contingency	8	-
Total	**60**	**58**

3.3 The Toronto Deep Lake Water Cooling System (DLWC)

Figure 3-10. Image Showing Intake pipes for the Toronto Deep Lake Cooling System Being Towed into Lake Ontario before Flooding and Installation at Depth

Interest in deep lake water cooling (DLWC) in the Toronto area has an extensive history. An initial study was conducted in 1981 for the Canada Mortgage and Housing Corporation. The study concluded that DLWC was feasible.

Although the potential for DLWC was presented to the Toronto City Council and the report was updated by the Ontario Ministry of Energy, no major private investor could be found to finance the project. However, the city needed to improve outdoor air quality, reduce greenhouse gas emissions and reduce electricity demands, and reduce the city's reliance on chlorofluorocarbon (CFC) and hydro chlorofluorocarbon (HCFC) refrigerants to comply with the Montreal Protocol. With the support of the Canadian Urban Institute, detailed environmental and technical studies were carried out and a conference was held in the early 1990s to demonstrate the opportunities for DLWC.

The former Municipality of Metropolitan Toronto worked with the Toronto District Heating Corporation (TDHC) (predecessor to Enwave) to explore the possibility of placing district cooling systems in the City of Toronto railway lands as an alternative to cooling towers.

The City of Toronto remained interested in the potential to harness the cold energy in the lake and an environmental assessment was completed in 1998. A total feasibility and engineering design was completed at a cost of $3.5 million. Funding for the effort was by shareholders and the Department of Natural Resources Canada in the form of a grant. The Federation of Canadian Municipalities provided a capital works loan of $10 million from the Green Municipal Fund at market rates which has been fully repaid by Enwave.

The reports that were prepared during the initial phase to develop the project are as follows:

1 *Deep Lake Water Cooling Schedule B Class Environmental Assessment* - Volumes I and II - May 1998.
2 *Interim Report on DLWC Temperatures* - October 1999.
3 *Deep Lake Water Cooling Pre-Engineering Report* - Volumes I, II and III - August 2000.
4 *The Potential for District Energy in Metropolitan Toronto* - March 1995.
5 *Global Warming Benefits of Deep Lake Water Cooling and District Cooling* - April 1997.
6 *Deep Lake Water Cooling* - July 1997.
7 *Zebra Mussel Monitoring Services* - August 1999.

3.3.1 DLWC - Geotechnical Reports

1 *Marine Geophysical Investigations for Deep Lake Water Intake South of Toronto Islands* - December 1998.
2 *City of Toronto Western Beaches Tunnel Geotechnical Baseline Report* - December 1996.
3 *Design and Construction of the Western Beaches Tunnel: Technical Proposal Volume One - Item A to N* - December 1997.
4 *Geotechnical Report: Western Beaches Tunnel - Alternative Tunnel Alignment* - November 1998.
5 *Soil Characterization and Groundwater Management - Precinct B* - May 1991.
6 *Toronto Deep Lake Water Cooling Project - Marine Geophysical Survey Results* - Fall 2000.

3.3.2 DLWC - Environmental Reports

1 *Pre-Design and EA Coastal Engineering Report, In Deep Lake Water Cooling Schedule B Class Environmental Assessment*, Volume 2 - Appendices - 1998.

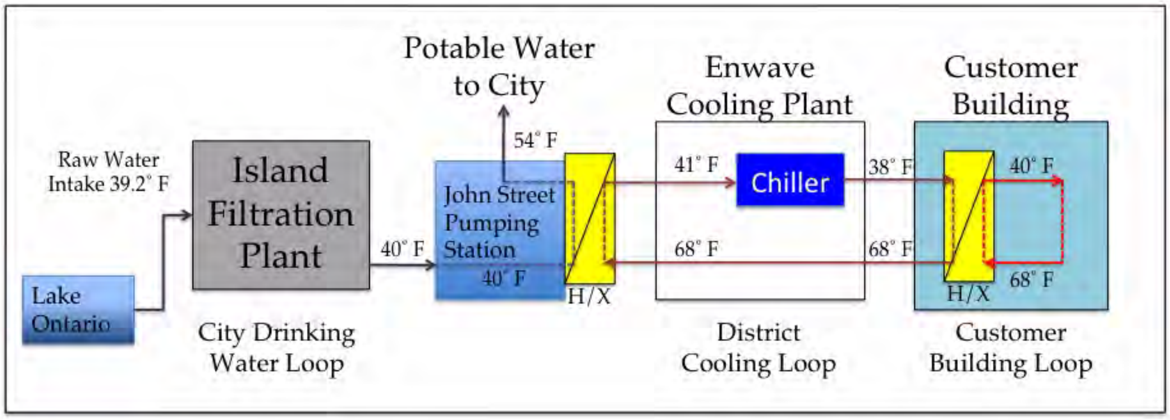
2 Appendix B - Environmental Reports, In Deep Lake Water Cooling Schedule B Class Environmental Assessment, Volume 2 - Appendices - 1998.

Part of the challenge of implementing the DLWC project was convincing government regulators that the extraction of a natural resource - water - which would normally be subject to a fee for industrial use should be exempt from fees. The project as it was being considered would facilitate the energy transfer by replacing the Toronto Island Filtration Plant water intakes with new deeper intakes and transfer the cold energy from the potable water system to the closed chilled water supply loop. With this business case, the regulators were convinced that no more water was being extracted from Lake Ontario than before and waived a levied fee for water extraction. In other words, DLWC uses cold from the water, not the water itself.

DLWC provides a simple cooling option, utilizing a natural and renewable resource. It uses the cold, deep water of Lake Ontario to cool a closed loop chilled water system. DLWC also offers a 75- to 100-year system life, instead of the 25-year average life typical for chillers according to ASHRAE.

DLWC consists of three 63-inch HDPE intakes taking cold water five kilometers (3.1 miles) off shore at a water depth of 83 meters (270 ft) below the surface. The three intakes are placed 1.5 kilometers (~ 1 mile) apart to allow for individual isolation in the event of environmental contamination. At depth that water is drawn at 4 ^{o}C (~39^{o}F) by the Toronto Island Filtration Plant, treated and forwarded to the City's John Street Pumping Station. There the coldness of the lake water is transferred through eighteen pairs of heat exchangers to the closed-loop chilled water distribution system. The heat exchangers consisting of over eight hundred stainless steel plates each are designed to transfer energy, not water. Once the treated water passes through the heat exchangers the water enters the City's potable water supply system not warmer than 12.5 ^{o}C (~55 ^{o}F) as a result of the heat transferred from the chilled water side of the heat exchanger. To ensure that the chilled water side of the heat exchanger cannot contaminate the City's potable water side, the City's side of the heat exchanger operates at a higher system pressure. A schematic representation of the system is shown on Figure 3-11.

Figure 3-11. Schematic of the Toronto Deep Lake Water Cooling System Showing Relationship to Potable Water System.



Note: Enwave is the for-profit corporation that manages the cooling district.

The chilled water system can bypass the cooling plant and continue to the distribution system. If necessary, water can be further chilled by two 4,700-ton steam-driven centrifugal chillers.

The chilled water distribution system consists of 10.6 kilometers of piping. The majority of the distribution piping is housed in large diameter tunnels bored deep in the rock well below the infrastructure of the City. Once at a customers building, a building heat exchanger cools the internals of the building.

3.3.3 Benefits of DLWC

3.3.3.a General Benefits

- Provides air-conditioning to residential, commercial, retail, institutional, governmental buildings and major sports facilities.
- Price-competitive service is sustainable, clean, and renewable.
- Extends municipal infrastructure and reduces strain on electricity infrastructure, including the transmission grid.
- Provides residents with an improved source of water supply that is cleaner and cooler (the algae smell in summer water has been eliminated).

3.3.3.b Environmental Benefits

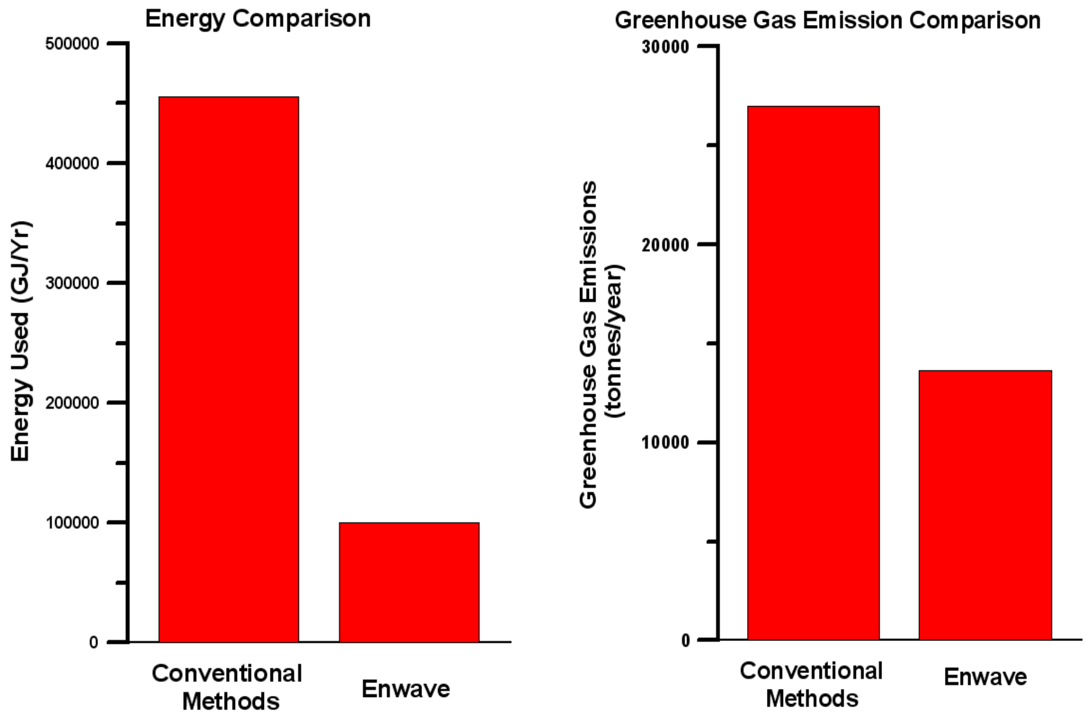
- Reduces electricity usage by 90 percent compared to a conventional cooling system. The system uses 85 million kilowatt-hours per year less than a conventional cooling system.

- Frees up more that 61 MW of electricity for the electrical grids.
- 79,000 tonnes (87,000 tons) of carbon dioxide are removed from the air annually (based on the displacement of coal and a full system build out) - equivalent to taking 15,800 automobiles off the road.
- Over 1,880 litres per second (500 gallons per second) of lake water cooling demand avoided due to reduction in the electricity generation.
- Removes 145 tonnes (160 tons) of nitrogen oxide and 318 tonnes (350 tons) of sulphur dioxide from the atmosphere relative to the use of coal-fired electricity.
- Reduces the need for cooling towers, thus relieving valuable commercial office space for other uses and saving some 714 million litres (190 million gallons) of fresh potable water.
- Buildings that convert to use DLWC can decommission older electrically driven refrigeration systems that contain CFCs and HCFCs.
- Enhances Toronto's world-class reputation as a place to live, provides cleaner air for breathing and makes Toronto a leader in sustainable energy.
- Decommissioning of Lakeview Coal Fired Generating Plant as part of a government mandate when DLWC was implemented. The Plant was just west of Toronto at the western end of Lake Ontario. Direct environmental benefit to the entire community.

3.3.3.c Economic Benefits

- Use of renewable energy source reduces the potential for rate increases and is free of influence from volatile energy markets.
- Estimated to generate 1,000 person-years of local labor in construction.
- Lower energy costs for customers.

Figure 3-12. Graphs Illustrating Benefits of Toronto System in Terms of Energy Consumption (left) and Greenhouse Gas Emissions (right)



The first customers for DLWC were the Air Canada Centre and the Metro Toronto Convention Centre. The first office complexes were the Oxford Buildings and the Royal Bank Plaza which came on line in July 2004. The successes of the first users of DLWC contributed to attracting additional customers and enabled Enwave to become the largest provider of district cooling in North America with 50 customers signed and 30 buildings connected to the system.

The system is designed to air condition nearly 3.2 million m^2 (34 million ft^2) of office space. The systems can provide 75,000 tonnes (83,000 tons) of connected refrigeration demand.

3.3.4 Construction

All impacts from construction were characterized as short term and minor in nature. The HDPE pipeline was fused and had stiffening rings and ballasted anchor block installed in the Bay of Quinte, just east of Belleville, Ontario. The assemblies were floated westward to the Toronto area for temporary storage just prior to deployment. Near shore dredging of a common trench was required to keep the top of the intake pipeline near shore below safe boating depth and ice scouring. Impacts from pipe laying operations on the lake were very limited to pleasure crafts having to pass Toronto Island further south into the lake to stay out of the patrolled exclusion zone for pipeline deployment.

3.3.5 DLWC Cost

The total cost of the DLWC project was $238 million with the marine component at approximately $60 million. Cost estimating for the project involved a combination of engineer's estimates, vendor quotes and contractor pricing. The project is designed for a 100 year life minimum.

3.4 Section Summary

The Cornell and Toronto naturally chilled water systems provide important guidance to the project team as summarized in the following list.

- The Cornell system demonstrates the feasibility of a Central New York finger lake as a source of naturally chilled water.
- The Cornell system demonstrates the benefits of separate systems for chilled and potable water.
- The Toronto system demonstrates the feasibility of a Lake Ontario source for naturally chilled water.
- The Toronto system demonstrates the feasibility of, and safeguards appropriate for, a chilled water system utilizing treated water first for its thermal properties and then as potable water.
- Both systems illustrate the availability of robust mechanical and control equipment as system components.

3.5 Section Glossary

Table 3-2. Terms Used in Section 3 and Their Definitions

304 stainless steel (20)	The most common and versatile grade of stainless steel; also known as 18/8 stainless steel.
API (6)	American Petroleum Institute, a national trade institute providing standards and specification for oil, natural gas, piping, tanks, pumps, etc.
API Standard 610 (5)	A standard specifying requirements for centrifugal pumps.
API5L Gr X65 (5)	A standard covering welded and seamless pipe suitable for use in conveying gas, water, and oil in both the oil and natural gas industries. Gr X65 indicates the grade of steel having a maximum yield strength of 65,000 psi.
ASHRAE (26)	American Society of Heating, Refrigerating and Air-Conditioning Engineers. An international technical society organized to advance the arts and sciences of heating, ventilation, air-conditioning, and refrigeration.
AWWA (20)	American Water Works Association. International nonprofit scientific and educational society dedicated to the improvement of drinking water quality and supply.
biomonitoring (10)	The process of inferring the ecological condition of an area by examining the organisms that live there.
BTU (5)	British Thermal Unit, equal to about 1.06 kilojoules and is defined as amount of heat required to raise the temperature of one pound of liquid water by one degree from 60° to 61° F at a constant pressure of one atmosphere.
BTU/hr (5)	British Thermal Units per Hour used as a unit of power of heating and cooling systems.
CFCs (3)	Chlorofluorocarbons. Compounds once used widely as aerosol propellants and refrigerants. CFCs are very stable in the troposphere. They move to the stratosphere and are broken down by strong ultraviolet (UV) light, where they release chlorine atoms that then deplete the ozone layer.
CHP (10)	Central Heating Plant, specifically the Cornell Central Heating Plant, which provides steam to the campus community for space heating and hot water and research.
cooling capacity (2)	The cooling power of an air conditioner. It is most commonly measured as the BTUs per hour of heat that the air conditioner can remove from the air. Cooling capacity can also be rated in tonnage. One ton of cooling equals 12,000 Btu heat removal per hour.
design duty (7)	The maximum efficiency of a centrifugal pump, determined by the flow rate and the total head at a respective pump speed.

Table 3-2. Terms Used in Section 3 and Their Definitions

DLWC (24)	Deep Lake Water Cooling. The practice of using cold water pumped from the bottom of a lake as a heat sink for climate control systems. Operated by the Enwave Energy Corporation in Toronto, Ontario, drawing water from Lake Ontario.
EIS (4)	Environmental Impact Statement. A statement from federal agencies required by The National Environmental Policy Act (NEPA) that integrates environmental values into the decision making processes by considering the environmental impacts of proposed actions and reasonable alternatives to those actions. An EIS describes the positive and negative environmental effects of proposed agency action.
FSAC (13)	Faculty Scientific Advisory Committee. An interdisciplinary group of faculty scientists at Cornell University formed to investigate the potential impacts of construction, water chemistry changes, biological effects and thermal impacts of using lake source cooling with Cayuga Lake as the source water body.
gpm (7)	Gallons per minute. A unit of volumetric flow rate.
HCFCs (24)	Hydro chlorofluorocarbons. A compound consisting of hydrogen, chlorine, fluorine, and carbon. HCFCs are one class of chemicals being used to replace the CFCs.
HDPE (7)	High Density Polyethylene. HDPE is a thermoplastic made from petroleum. Having a wide variety of applications it is harder, stronger and a little heavier than the low density form, but less ductile.
head (6)	A measurement of water pressure above a reference point. A concept in fluid dynamics that relates the energy of an incompressible fluid to the height of an equivalent static column of that fluid. Head is expressed in units of height such as meters and feet.
Heat Exchanger	A device used for efficient heat transfer from one medium to another. In this case where the media are separated by a solid wall so that they never mix. The heat exchangers used here are plate-and-frame heat exchangers. Plate-and-frame heat exchangers are composed of multiple, thin, slightly separated plates that have very large surface areas and fluid flow passages for heat transfer.
HEF (19)	Heat Exchange Facility. The building or facility which houses all the components of the heat exchange process including the intake wet well, lake intake and outfall piping, chilled water piping, plate and frame heat exchangers, pumps and a control room.

Table 3-2. Terms Used in Section 3 and Their Definitions

HFC (4)	Hydrofluorocarbon. A compound consisting of hydrogen, fluorine, and carbon. HFCs are a class of replacements for CFCs in refrigeration. Because they do not contain chlorine or bromine, they do not deplete the ozone layer.
horsepower (6)	A common unit of power, defined as the amount of work done over time. In the British Imperial System, one horsepower equals 33,000 foot-pounds of work per minute or the power necessary to lift a total mass of 33,000 pounds one foot in one minute. The electrical equivalent of one horsepower is 745.7 watts.
HVAC (20)	An acronym that stands for heating, ventilating, and air conditioning. HVAC is sometimes referred to as climate control and refers to a central air system for heating and cooling a building. This generally includes a furnace, blower assembly, an evaporative coil, a compressor and compressor coil, and air ducts to distribute the conditioned air within the building. It is particularly important in the design of medium to large industrial and office buildings such as skyscrapers.
IGBT (10)	Insulated Gate Bipolar Transistors. A three-terminal power semiconductor device, noted for high efficiency and fast switching. An IGTB switches the DC bus on and off at specific intervals creating a variable AC voltage and frequency output.
impeller (9)	A rotating component of a centrifugal pump which transfers energy from the motor that drives the pump to the fluid being pumped by accelerating the fluid outwards from the center of rotation. The velocity achieved by the impeller transfers into pressure when the outward movement of the fluid is confined by the pump casing.
internal pipe friction (6)	Friction between the internal wall of a pipe and the fluid in the pipe which can result in decreased flow in the pipe.
Kanusa shrink sleeves (21)	Heat shrinkable sleeves for corrosion protection of high profile joints such as flanges, casings, bell and spigot joints.
Kilowatt-hours (3)	kWh. A unit of energy equal to 3.6 megajoules or 3412.1416 BTUs. Energy in kilowatt hours is the product of power in kilowatts and time in hours; it is not kilowatts per hour.
kV (10)	kilovolt or 1000 volts. The volt is the SI derived unit of electromotive force, commonly called “voltage.” The volt is defined as the value of the voltage across a conductor when a current of one ampere dissipates one watt of power in the conductor.

Table 3-2. Terms Used in Section 3 and Their Definitions

kWh/ton-hour (2)	Kilowatt-hours per ton hour, the amount of energy in KWh to produce a ton-hour of cooling, can be used as a measurement of efficiency.
llitres per second (28)	A unit of flow rate. One l/s is equal to 0.264 gallons/second
LMTD (7)	Log mean temperature difference, used to determine the temperature driving force for heat transfer in heat exchangers. The LMTD is a logarithmic average of the temperature difference between the hot and cold fluid at each end of the exchanger. The larger the LMTD, the more heat is transferred.
LSC (3)	Lake Source Cooling. Technology using the deep cold water from a lake to replace mechanical chillers in a central chilled water system central campus chilled water system.
Montreal Protocol (24)	An international agreement designed to protect the stratospheric ozone layer by phasing out the production of substances believed to be responsible for ozone depletion. The treaty, signed in 1987, stipulates that the production and consumption of compounds that deplete ozone in the stratosphere--chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform--are to be phased out by the year 2000.
MW	Megawatt - One million watts. A watt is a unit of power and describes the rate at which energy is used.
mysids (16)	Mysidacea is a group of small, shrimp-like creatures sometimes referred to as opossum shrimps. The specific species Mysis relicta is the only member of the order Mysidacea found in the Great Lakes Region. It is a very important food source for many species of fish.
Nitrogen oxides (5)	Any binary compound of oxygen and nitrogen. Nitrogen oxides (NOx) form when fuel is burned at high temperatures as in a combustion process. The most important forms of reactive nitrogen in the air are nitrogen monoxide (NO) and nitrogen dioxide (NO_2) and together are called NOx.
Phase I Feasibility Investigation (4)	A preliminary study of the viability of an idea project, or concept. It defines what strategic issues need to be considered to assess its likelihood of succeeding.
Phase II Schematic Design and Permitting (4)	A critical phase where expectations are set, budget and schedule are established and the appropriate regulatory permits are filed. Schematic design determines the general scope, preliminary design, scale and relationships among the components of the project, design of engineering schematics and development of an Environmental Impact Statement (EIS).

Table 3-2. Terms Used in Section 3 and Their Definitions

Phase III Final Design and Construction (5)	The final phase of a project. Detailed architectural and engineering drawings (blueprints) of all physical components of the project are produced and construction begins.
pigging (8)	The process of cleaning distribution lines by inserting a small device known as a pig into the lines and pushing it through them. The term “pigging” originated in the gas and oil industry, where metal discs connected by a rod were moved through the oil pipelines to remove buildup of paraffin wax on the internal wall of the pipe. The action of metal on metal made a squealing noise like a pig and the name stuck.
Plankton net (10)	A funnel-shaped, fine-meshed net that is towed through the water. The net concentrates the plankton from the water that pass through it. Used here the plankton net is stationary and water is pumped through it as a means of monitoring entrainment of aquatic organisms.
PLC (10)	Programmable Logic Controller. A digital computer used for automation of electromechanical processes, such as control of machinery. PLCs are the control hubs for a wide variety of automated systems and processes. They contain multiple inputs and outputs that use transistors and other circuitry to simulate switches and relays to control equipment. They are programmable via software interfaced via standard computer interfaces and proprietary languages and network options.
Polyken YGIII (21)	A multilayer coating system used primarily for the protection of steel and ductile iron water pipelines.
psi (7)	Pounds per square inch (pound-force per square inch), is a unit of pressure or of stress based, it is the pressure resulting from a force of one pound applied to an area of one square inch
PWM (10)	Pulse Width Modulation, is a very efficient way of providing intermediate amounts of electrical power between fully on and fully off.
rpm (6)	Revolutions Per Minute, is a unit of frequency often used to measure rotational speed. It is the number of full rotations completed in one minute around a fixed axis.
RTU (12)	Remote Terminal Unit, is a microprocessor controlled electronic device used to connect directly to sensors, meters, loggers or process equipment and collect data automatically. They serve as slave units to supervisory controllers or supervisory control and data acquisition (SCADA) masters.

Table 3-2. Terms Used in Section 3 and Their Definitions

Sacrificial anode (19)	A metallic anode used in cathodic protection where it is intended to be dissolved to protect other metallic components. A sacrificial anode is more easily oxidized than the protected metal and corrodes first thus acting as a barrier against corrosion for the protected metal.
SEQRA (13)	State Environmental Quality Review Act. New York's SEQRA requires all state and local government agencies to consider environmental impacts equally with social and economic factors during discretionary decision-making.
soluble reactive phosphorus (14)	A measure of orthophosphate which is the filterable, soluble, and inorganic fraction of phosphorus, the form directly taken up by plant cells.
SPDES (15)	State Pollutant Discharge Elimination System. New York's SPDES is a program for the control of wastewater and stormwater discharges in accordance with the Clean Water Act. It is broader in scope than that required by the Clean Water Act in that it controls point source discharges to groundwaters as well as surface waters.
static head (6)	The maximum height or pressure that a pump can deliver.
Sulfur dioxide (5)	SO_2 belongs to the family of sulfur oxide gases (SOx). These gases dissolve easily in water. SOx gases are formed when fuel containing sulfur, such as coal and oil, is burned, and when gasoline is extracted from oil. SO2 dissolves in water vapor to form acid, and interacts with other gases and particles in the air to form sulfates and other potentially harmful products.
system life	Amount of time a mechanical system can be operated before replacement is necessary.
ton-hours (2)	The unit of stored thermal energy for cooling. The refrigeration's capacity of one refrigeration ton during a 1 hour period.
tonnes (28)	A metric ton; a measurement of mass equal to 1,000 kg or 2,204 or approximately the mass of one cubic meter of water.
tons (2)	As a unit of mass it is equal to 2000 pounds. Also known as a short ton. In terms of refrigeration the ton is used in refrigeration and air conditioning to measure heat absorption. A ton of cooling is approximately the power required to melt one short ton (2000 lb) of ice at 0 °C in 24 hours, equal to 12,000 Btu heat removal per hour.
total phosphorus (14)	TP is a measure of all the various forms of phosphorus that are found in a water sample. Phosphorus is an element that, in its different forms, stimulates the growth of aquatic plants and algae in waterbodies.

Table 3-2. Terms Used in Section 3 and Their Definitions

turbidity (15)	A measure of the degree to which the water looses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the more opaque it appears and the higher the turbidity. Turbidity is often used as a measure of the quality of water.
VAC (10)	Volts of Alternating Current. In alternating current (AC) the flow of electric charge periodically reverses direction. AC refers to the form in which electricity is delivered to businesses and residences.
volute (6)	The casing of a centrifugal pump that receives the fluid being pumped by the impeller, slowing down the fluid's rate of flow. The volute converts kinetic energy into pressure by reducing speed while increasing pressure, helping to balance the hydraulic pressure on the shaft of the pump.
wet well (8)	A chamber used for collecting lake water. The wet well hydraulically separates the plant piping from the lake intake pipe. Submersible pumps are housed in the wet well and pump the water into the plant. As the water level drops in the wet well lake water enters by gravity.
zebra mussels (8)	*Dreissena polymorpha*, are small bivalve shellfish named for the striped pattern of their shells. They are typically found attached to objects, surfaces, or each other by threads underneath the shells. Zebra mussels are notorious for their biofouling capabilities by colonizing water supply pipes of hydroelectric and nuclear power plants, public water supply plants, and industrial facilities Zebra mussels represent one of the most important biological invasions into North America, having profoundly affected the science of Invasion Biology, public perception, and policy.

4.0 Economic Profile of Central New York

4.1 Section Introduction

In this section we review the recent and current economic and population data to describe the Central New York region. We depict the types of industries, and the employment associated with each type, and note trends as appropriate.

4.2 Essential Economic Characteristics - Onondaga and Oswego Counties

Onondaga and Oswego Counties form the core of a stable, economically and socially diverse Central New York (CNY) region. The two counties have a total land area of 2,118 square miles and a combined population of 579,854 (est. 2006). Since 1990, the population has declined by approximately 2%; however, there has been a moderating trend over the past several years. While the combined counties registered a 0.14% population decline since 2000, Oswego County actually experienced a 1% gain in population since 1990.

Although the area has been negatively impacted by declines in manufacturing employment, including the transfer of Carrier Corporation's manufacturing operation out of the area, these declines have been offset by growth in service sector employment. In particular, the employment base is bolstered by the presence of growing health care and higher education sectors. Employment in the areas of wholesale and retail trade is also anticipated to benefit from the planned expansion of Carousel Center, the existing regional mall, into a multipurpose venue named DestiNY USA. Unemployment rates have consistently been below state and national levels and registered 5.7% compared to a 5.8% rate for New York State in August 2008. Median household income levels are slightly below state and national levels.

From the perspective of an industry considering a CNY location, the region has several key attributes of interest. It is often favorably profiled for its strategic location at the intersection of I-90 (east-west) and I-81 (north-south) and serviced by a major railroad (CSX) and the international airport at Hancock Field; the large and diversified base of educational resources; a trained and well-educated work force; and generally high marks on many key quality of life indicators. These attributes are seen as comparative advantages for the region and also tend to rank highly on site selection criteria listings.

The profile information discussed below will review the basic economic data that are important both in evaluating the possible use and the benefit of a deep lake naturally chilled water project (NCW) and in determining the attractiveness of the region as a location for new businesses. Following that discussion and analysis, the four key regional economic strengths identified above will be reviewed in greater depth. In this way, the attractiveness of the NCW as an economic development driver can be understood within the context of factors that are typically considered when evaluating an area as a location for a new or expanding business.

4.3 Background Economic Information

The Central New York economy is diverse and relatively stable, building on key industries that were formed over the past century. The primary industries include manufacturing, financial services (banking, insurance and investment) that serve the region and some with national focus, educational institutions, health care, governmental agencies, and regional retail and wholesale outlets.

According to the United Stated Bureau of Economic Analysis (USBEA), in 2006 the Metropolitan Syracuse Area (MSA), which includes Oswego, Madison and Onondaga counties, generated an estimated $24.4 billion in goods and services, which represented an output of $33,200 per capita. By this reckoning, the Onondaga-Oswego portion of the MSA generated over $19 billion.

Onondaga County, from the beginning of World War II, had steady job growth as the industrial and commercial base expanded due to the ramp-up of war production at General Electric, Carrier and other materiel suppliers. As a result of the Baby Boom after the war, job growth continued through the 1950s. During the late 1970s and early 1980s manufacturing jobs started to decrease as result of a slumping economy and plant closures. More recent stalled job growth is due to maturing product lines of major manufacturers, and significant relocation of manufacturing capacity and jobs to other regions and countries as businesses compete in a global marketplace.

4.4 Population Trends

There has been essentially no population growth in the Onondaga/ Oswego County region since 1980. This stagnant scenario has come about as Onondaga County's population has declined while Oswego County has shown regular if slowing growth over the period (Table 4-1). A significant exodus of people occurred during the 1990-2000 period with the area losing approximately 1.7% of its population. A moderating trend is evident in the current decade with overall population declining by 0.15%. Both counties experienced positive natural population growth and international migration but the trend of domestic out-migration continued, albeit more slowly of late. Table 4-2 shows data form the Syracuse region as compared to national and state trends.

Table 4-1. Population Trends - Onondaga and Oswego Counties

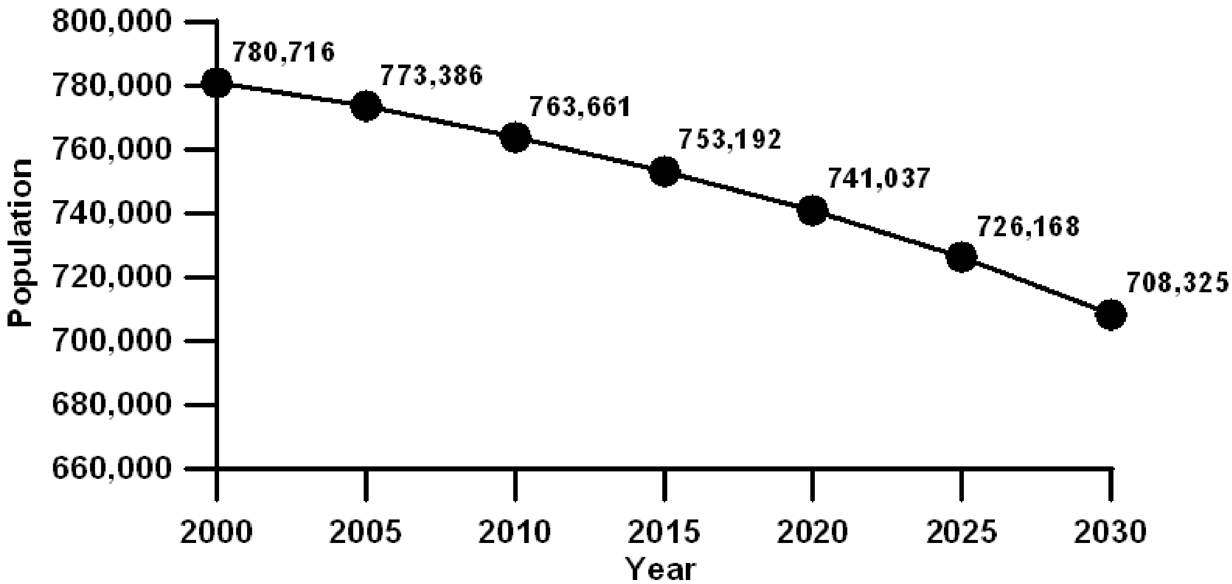
Year	Oswego	Onondaga	Combined
1980	113,901	463,920	577,821
1990	121,771	468,973	590,744
2000	122,377	458,336	580,713
2009	121,377	454,753	576,130

Table 4-2. Comparative Population Data: United States, New York State, and Syracuse MSA

	1980	1990	2000	2009	Percent Change
United States	226,500,000	248,700,000	281,400,000	307,006,550	35.5%
New York State	17,600,000	17,900,000	18,900,000	19,541,453	11.0%
Syracuse MSA	642,900	659,900	650,100	646,083	0.5%
Syracuse MSA 2009 definition included Oswego, Madison and Onondaga Counties					

Population projections for the area generally predict a decline. A 2003 projection from the Cornell Institute for Social and Economic Research forecasts a 9.3% decline in population for the five-county CNY region between 2000 and 2030 (Figure 4-1). Projections available for other counties in upstate New York exhibit similar trends of overall population decline over time.

Figure 4-1. Central New York Population Projections (Cayuga, Cortland, Madison, Onondaga, and Oswego Counties) Source: Cornell University Institute for Social and Economic Research



Naturally, projections depend on the continuance of trends evident at the time the projections are made. As the fundamentals of underlying economic and demographic trends continue to evolve, new influences on population trends in the region will have to be considered. Other factors, such as immigration may also play a role in the direction of population growth in the region, although it should be noted that New York as a whole has one of the lowest rates of in-migration in the country, according to the Census Bureau.

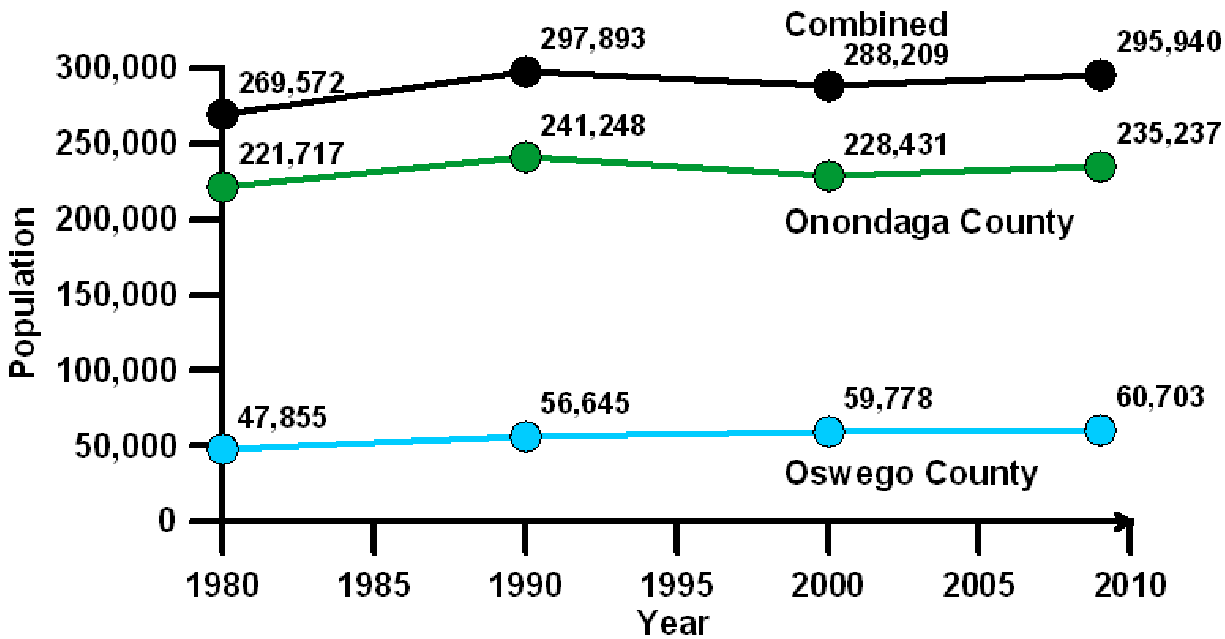
Figure 4-2 shows the population and population densities of towns and cities in the Central New York region.

Figure 4-2. Population and Population Densities for Cities and Towns in Central New York.

4.5 Trends in Work Force Size and Characteristics

Of critical importance to any area seeking economic expansion is the size and make-up of its work force (Figure 4-3). The availability of a trained work force is frequently cited as a main reason for positive site selection decisions.

Figure 4-3. Size of Labor Force - Onondaga and Oswego Counties



The size of the regional work force, defined as individuals over the age of 16, has shown growth over a period of population decline. For the Onondaga/ Oswego region, the available work force has grown by slightly more than 8% since 1980. The period between 1990 and 2000 actually showed a reduction in the number of people available for work, but some of these losses have been made up since 2000.

The region's well-educated and trained work force is often cited as an attractive attribute for businesses looking to expand or move to the area. Table 4-3 summarizes the educational attainment levels of the population over the age of 25. Similar data for the United States, New York State and other upstate communities are presented for comparison in Table 4-4.

Table 4-3. Educational Attainment of Population 25 Years and Older (2009)

	Oswego	Onondaga	Combined
< 9th Grade	2,938	9,747	12,685
9th to 12th, no diploma	8,062	23,882	31,944
High school graduate	33,263	84,536	117,799
Some college	14,878	54,375	69,253
Associate degree	7,500	33,762	41,262
Bachelor degree	7,426	54,535	61,961
Graduate or professional degree	4,609	40,456	45,065

Table 4-4. Percentage of Population Over 25 Attaining High School Diploma and College Level Degrees (2009)

	High School Diploma	Bachelor Degree or Higher
United States	84.6	27.5
New York State	84.2	31.8
Albany MSA	90.2	32.1
Rochester MSA	88.3	31.2
Onondaga and Oswego Counties	88.3	**28.2**
Syracuse MSA	88.3	27.7
Buffalo MSA	87.9	26.7
Utica MSA	85.8	20.3
Source: American Factfinder, U.S. Census Bureau		

The Onondaga/Oswego region compares favorably to national and state regions. In regard to comparisons with other upstate areas, Onondaga/ Oswego falls into the middle of the rankings, with a higher percentage of the population reporting High School diplomas-only compared to Rochester and Albany but a greater percentage of college level graduates than in the Buffalo or Utica MSAs.

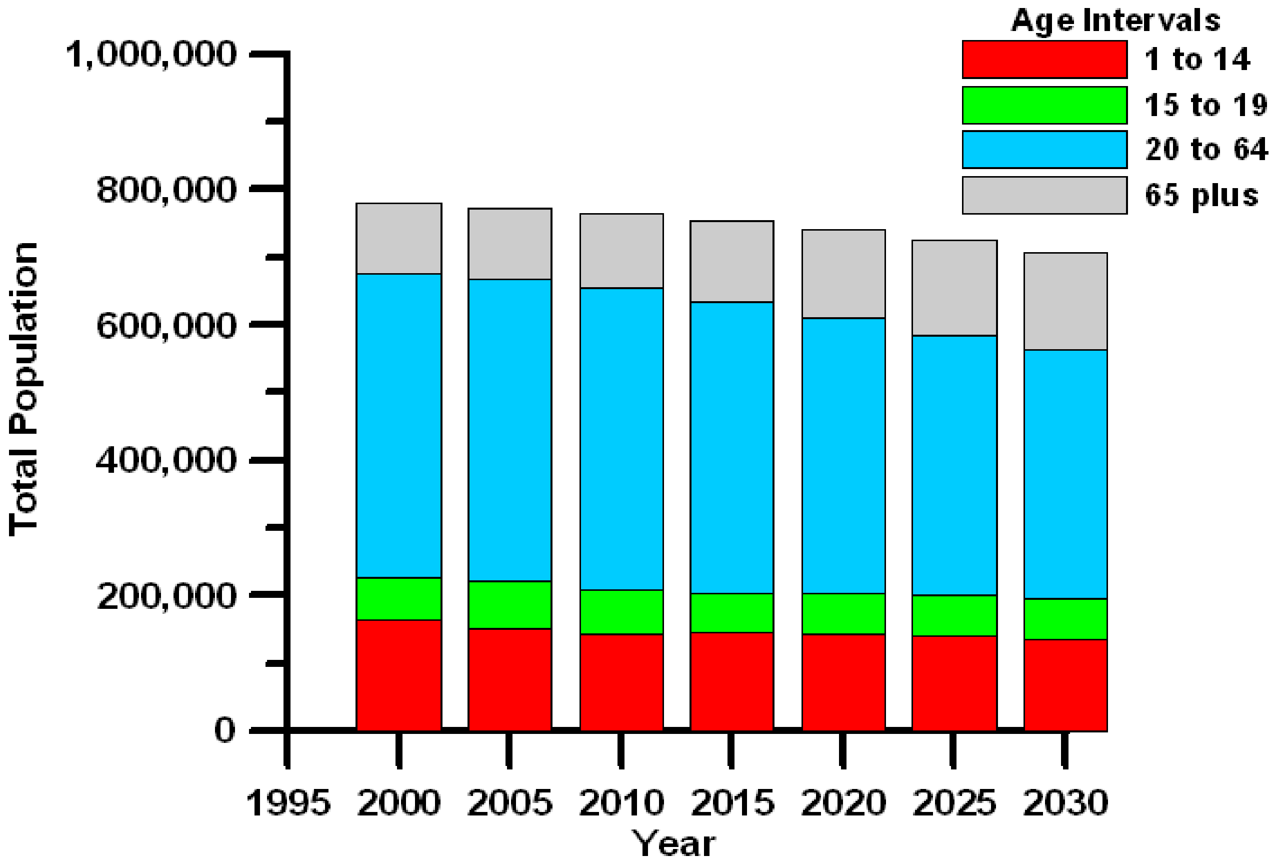
A sustained loss or stagnation in population eventually decreases the available labor supply as the remaining population matures. This, in turn, naturally increases the median age of the work force and changes the profile of the region with regard to the types and numbers of jobs that can be created or attracted to the area. Given the net out-migration pattern for the region and the fairly rapid increase in the median age of the work force as noted in Table 4-5, it is reasonable to assume that the Onondaga/Oswego region is losing a significant portion of it younger workers to opportunities in other geographic areas.

Table 4-5. Median Age (Oswego, Onondaga, New York, United States)

Year	Oswego	Onondaga	New York	United States
1990	30.5	32.8	33.8	32.9
2000	35.0	36.8	35.9	35.3
2009	37.8	38.4	37.7	36.5

At least one forecast anticipates that this trend will continue and accelerate in coming decades. The graph below (Figure 4-4) uses data from the Cornell Institute for Social and Economic Research and shows not only an expected decline in the overall population for the five-county region but a significant shrinkage in the number of 20 to 64 year-olds in the population.

Figure 4-4. Central New York Population Projections by Age Group (Cayuga, Cortland, Madison, Onondaga and Oswego Counties)



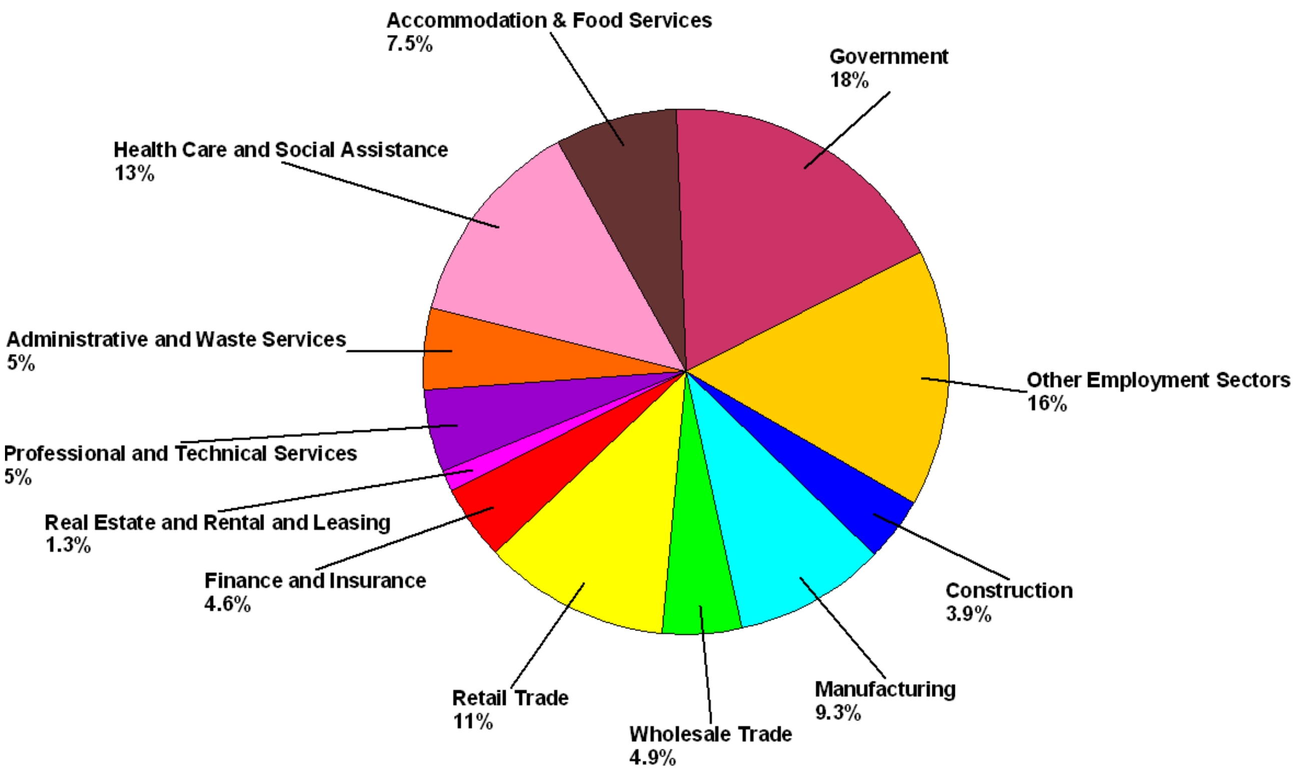
The decline in the number of 20 to 64 year olds in the population will affect the economy of Central New York in several ways. On the positive side, it is possible that opportunities for the unemployed work force will increase as the available work force decreases. Conversely, Central New York employers will have a harder time finding enough workers to fuel the modest job growth (0.7% annually) projected for Central New York through 2014. Employers who cannot grow jobs in Central New York may look elsewhere for future expansions. Firms that face a tight labor market in other parts of the United States will continue to seek new locations where workers are more plentiful. Without a sufficiently large demographically attractive work force, Central New York may no longer be a desirable location for these companies. Net in-migration to fill vacancies may be able to maintain jobs in the region as might training programs targeted at specific sectors, but as pointed out previously, the current migration patterns for the region have been negative.

In addition to the demographic data on the state of the work force, it is also important to understand how the work force is currently engaged in the local economy, e. g., what industries, trades and professions predominate and what has been the trend in either their growth or decline over time. In many cases, the sector-based concentrations of the current work force will influence the types of industries that flourish or concentrate in the region. Figure 4-4 reviews the trends and current status of the regional work force with regard to occupation.

4.6 Employment by Major Economic Sector - Current and Historical Trend

Figure 4-5 depicts the composition of the Central New York (Syracuse Auburn Consolidated Statistical Area (CSA)) economy for 2007 broken down by two-digit North American Industry Classification System (NAICS) code.

Figure 4-5. Employment in Onondaga & Oswego Counties by NAICS Code (2009)



As noted in the introduction, the Central New York region has a long history of manufacturing. Manufacturing continues to hold a significant position in the overall employment of Central New York residents. Yet this base of employment has been in steady decline. Recent changes in the patterns of employment by sector are shown in Table 4-6.

Table 4-6. Combined Employment by Sector: Onondaga and Oswego Counties

	2000	% of total	2005	% of total	2009	% of total	% change: 2000-09
Total, All Industries	286,879		282,402		275,873		-3.8
Total, All Private	238,696	83.2	233,526	82.7	225,978	81.9	-5.3
Construction	11,527	4.0	10,970	3.9	10,852	3.9	-5.9
Manufacturing	40,391	14.1	30,290	10.7	25,760	9.3	-36.2
Wholesale Trade	14,667	5.1	13,766	4.9	13,388	4.9	-8.7
Retail Trade	34,295	12.0	33,862	12.0	31,690	11.5	-7.6
Finance and Insurance	13,124	4.6	12,702	4.5	12,600	4.6	-4.0
Real Estate, Rental and Leasing	3,526	1.2	3,959	1.4	3,697	1.3	4.8
Professional/Technical Services	11,681	4.1	13,332	4.7	13,835	5.0	18.4
Administrative/Waste Services	12,775	4.5	14,475	5.1	13,862	5.0	8.5
Health Care/Social Assistance	29,910	10.4	33,888	12.0	35,881	13.0	20.0
Accommodation/Food Services	19,241	6.7	20,281	7.2	20,709	7.5	7.6
Government	48,183	16.8	48,876	17.3	49,895	18.1	3.6
Other Employment Sectors	47,659	16.5	46,001	16.3	43,704	15.8	-8.1
Source: New York State Department of Labor							

Some of the trends evidenced by these figures, particularly the decline in manufacturing employment and its share of the overall economic picture in CNY, go back much further. Figures for 1980 through 2000, adjusted for the conversion from Standard Industry Classification to NAICS beginning in 2000, would confirm the trends indicated above. These data, unconverted, are presented in Table 4-7 for informational purposes. While these figures are not directly comparable owing to source and classification differences, the trends represented are clear.

Table 4-7. Largest Industries in Major Employment Sectors, Cayuga, Cortland, Madison, Onondaga and Oswego Counties - 2009

	1980	1990	2000
Total full-time and part-time employment	287,021	350,568	348,368
Wage and salary employment	253,779	307,208	305,511
Proprietors employment	33,242	43,360	42,859
Farm proprietors employment	1,918	1,628	1,491
Non-farm proprietors employment	31,324	41,732	41,366
Farm employment	3,117	2,520	2,276
Non-farm employment	283,904	348,048	346,092
Private employment	237,995	298,773	295,401
Agricultural services, forestry, fishing, other	881	1,960	2,437
Mining	408	371	160
Construction	11,487	19,944	16,176
Manufacturing	58,438	49,772	43,305
Transportation and public utilities	15,604	17,485	17,777
Wholesale trade	19,626	19,775	19,642
Retail trade	42,377	60,218	58,985
Finance, insurance, and real estate	26,175	29,303	25,480
Services	62,999	87,487	108,486
Government and government enterprises	45,909	49,275	50,691
Federal, civilian	4,429	4,236	4,891
Military	2,685	2,158	1,446
State and local	38,795	42,881	44,354
State government	9,537	11,513	12,305
Local government	29,258	31,368	32,049

The decline in manufacturing employment, once the mainstay of the Central New York economy, has been a long and painful transition for the local work force. As noted earlier, the reasons for the decline are many and familiar and have to do as much with shifting global economic forces as with relative changes in local conditions. Manufacturing employment appears to have stabilized at approximately 10% of the local work force. While manufacturing still contributes significantly to the creation of local economic value, the shift to a service-oriented economy and a work force engaged in professional and technical occupations, health, social service and government jobs and retail is nearly complete.

4.6.1 Employment by Largest Industries Within Main Sectors

Within the larger components of economic activity reviewed in the data above, particular industries are significant players. Table 4-8 details the breakdown of Central New York's largest employment sectors into specific industries revealing certain critical clusters of employment and economic activity in the region. This provides more specific information on both the current attributes of the local economy and the likely skill sets that the local work force possesses.

A sizeable portion of the work force is still employed in the manufacturing sector, some in the “heavier” industries that have predominated in the local economy for years. The largest of those segments is in computer and electronic products.

The movement away from manufacturing and toward a more office-based, white collar economy can be seen to positively impact the proposal for a Naturally Chilled Water project in Central New York. There will certainly be fewer large-scale manufacturers in the local economy. Their demand for comfort cooling in the upstate New York climate is or will be minimal. One of the largest manufacturing segments remaining is in computer and electronic products, a sector that is frequently smaller scale and demands treated air and often cooler ambient temperatures because of electronic equipment operating requirements.

A white collar economy does its business in offices of all sizes and these locations require comfort cooling for a good portion of the year. Clustered office development, such as business parks, may provide sufficient load profiles to make service from a Naturally Chilled Water Project viable. Retail locations such as malls or shopping centers, hotels and hospitals are likewise dependent on air treatment and are frequently located in large or clustered structures requiring significant air treatment capabilities.

A list of the larger industries and institutions in Onondaga and Oswego Counties is shown in Table 4-8. This list was used to determine the existing cooling loads within the project area.

Table 4-8. Largest Industries in Major Employment Sectors, Onondaga and Oswego Counties - 2009

	Number Reporting	Employment	Total Wages
Manufacturing			
Chemical manufacturing	20	948	$74,882,253
Electrical equipment & appliances	15	1,088	$59,173,835
Paper manufacturing	14	983	$53,558,966
Fabricated metal product manufacturing	104	2,619	$131,391,488
Computer and electronic product mfg.	47	5,110	$385,440,223
Machinery manufacturing	45	2,318	$150,358,727
Miscellaneous manufacturing	44	2,201	$139,319,270
Retail Trade			
Food and beverage stores	301	7,836	$147,697,747
General merchandise stores	104	5,522	$101,447,710
Motor vehicle and parts dealers	257	3,737	$147,435,195
Clothing and clothing accessories stores	251	2,764	$40,428,114
Finance, Insurance and Real Estate			
Insurance carriers and related activity	406	8,113	$479,137,422
Credit intermediation and related activity	278	3,579	$168,397,356
Real estate	540	2,621	$81,617,163
Health Care and Social Assistance			
Ambulatory health care services	1001	12,856	$714,288,587
Nursing and residential care facilities	145	8,071	$222,680,148
Social assistance	326	6,747	$148,679,388
Government			
Local Government	355	7,854	$1,465,679,137
State Government	49	11,993	$446,999,129
Federal Government	123	4,436	$246,222,644
Source: New York State Department of Labor.			

4.7 Section Summary

Central New York is a stable, economically and socially diverse region, with a well-educated and trained work force (Tables 4-3, 4-4). In 2006, Onondaga and Oswego counties generated over $19 billion dollars of goods and services (Section 4-3). The diverse economy of the region is reflected in strengths in health and education, manufacturing, government (including education) and professional and business services (Figure 4-4). Overall, the manufacturing sector is decreasing with an increase in service sector employment (Tables 4-6, 4-7).

5.0 Energy Profile of Central New York

5.1 Section Introduction

The sources and uses of energy in Central New York are reviewed. In particular, data as to energy usage by economic sector is analyzed. Some of the detailed information (e.g., energy usage by zone within New York State) can be found in the Appendix to this section.

5.2 Energy Supply and Usage in CNY

According to the January 2008 New York State energy Research and Development Authority (NYSERDA) report, “Patterns and Trends: New York State Energy Profiles and Trends 1992-2006,” New York is the fourth largest energy user of all the states. Thirteen percent of the total primary energy requirements are met from in-State resources. Hydroelectric power is produced at various locations throughout New York, including 28 large projects and approximately 340 small (less than 10 MW) projects. Crude oil and natural gas production are found in the western region of the State. Bio-fuels are derived primarily from wood, wastes, and agricultural products. Households, businesses, industries, and electric utilities in New York rely largely on fuels produced elsewhere. Figure 5-1 is reproduced from the Energy Information Administration's State Profile for New York.

Figure 5-1. Sources of Energy in New York State

The **megawatt** (symbol: **MW**) is equal to one million (10^6) watts.

The **gigawatt** (symbol: **GW**) is equal to one billion (10^9) watts.

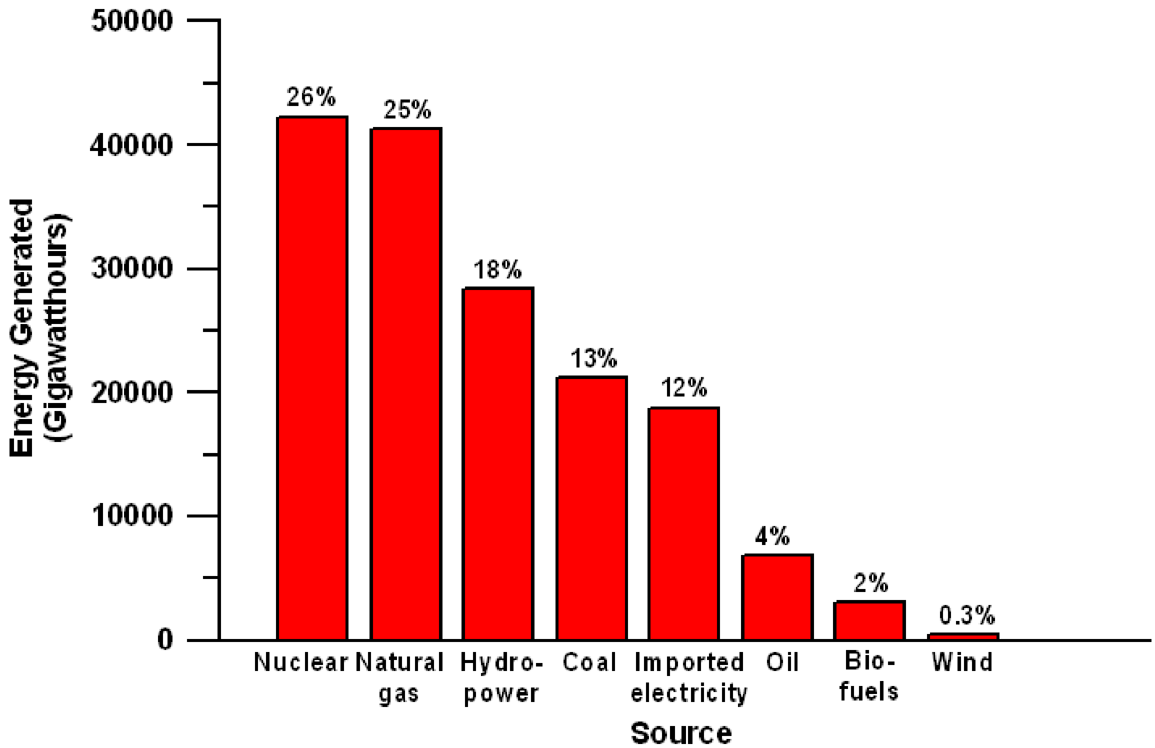
A **kilowatt-hour** is the amount of energy equivalent to a steady power of 1 kilowatt running for 1 hour.

The conversion ratio for **Btu/KWh** is 3,412:1.

5.2.1 Electricity Generation in New York

Figure 5-2 summarizes New York State's electricity generation capacity as of 2006. Unlike many states, New York does not rely heavily on any one fuel for electricity generation. Nuclear power, produced at New York's four nuclear plants, is the leading generation fuel, typically accounting for about one quarter of state generation. However, four other energy sources (natural gas, hydroelectric, coal, and petroleum) each account for a substantial share of the power generated in the State. New York is also a major net importer of electricity from neighboring States and Canada. According to NYSERDA, New York utilized approximately 18,750 GWh of imported electricity in 2006, or 12% of total electricity usage.

Figure 5-2. **Electricity Generation by Fuel Type and Source - New York State**



Lacking abundant supplies of carbon-based energy, NY has turned to its nuclear and hydroelectric resources and increasingly to renewable energy, such as wind, for a larger share of its energy needs. Demand and supply situations differ between upstate and downstate regions, with the downstate area in energy deficit and upstate in surplus. This imbalance, among other factors, has led to the NY Regional Interconnect proposal to construct new transmission lines linking upstate resources with downstate demand. There are fears that this transfer of energy produced locally for sale downstate will increase local energy costs.

The ability to substitute a local resource, such as Naturally Chilled Water (NCW), for imported electricity that would be used to run chillers, would be a desirable policy goal as well as a mechanism that would reduce energy consumption and possibly lower users' overall expenditures on energy.

5.2.2 Energy Usage In New York State

New York is the fourth largest energy consuming state. Yet it is also the second most energy-efficient state in the continental United States on a per-capita basis, behind Rhode Island, accounting for 4.1% of the nation's total primary energy consumption. New York accounts for 6.4% of the nation's population. Much of this efficiency likely stems from mass transit usage in the New York City region.

Table 5-1 summarizes energy consumption and expenditure patterns in New York State. Absent the amount of energy consumed and purchased for transportation, most of NY's energy is used in residential and commercial end uses. Energy for these uses is derived principally from natural gas and electricity (lighting and heating, primarily). While electricity accounts for 18% of the total fuel source used in NY (vs. 24% for natural gas) 35% of the dollars spent are spent on electricity and, in turn, on the nuclear, hydro and other generation sources.

Table 5-1. Energy Consumption and Expenditure Patterns in New York State

	Net Energy Consumption (Trillion BTU)		Estimated Expenditures (Billion Dollars)	
Total	**2,910.8**		**$59.5**	
By Sector				
Residential	773.5	27%	$17.4	29%
Commercial	694.2	24%	$15.7	26%
Industrial	242.0	8%	$3.3	6%
Transportation	1,201.0	41%	$23.2	39%
By Fuel Type				
Petroleum	1,515.2	52%	$29.0	49%
Natural gas	717.0	24%	$9.6	16%
Electricity	511.2	18%	$20.8	35%
Biofuels	125.6	4%		
Coal	41.7	2%	$0.1	1%
Estimated energy expenditures leaving the state			$30.5	
Source: NYSERDA, Patterns and Trends 2008.				

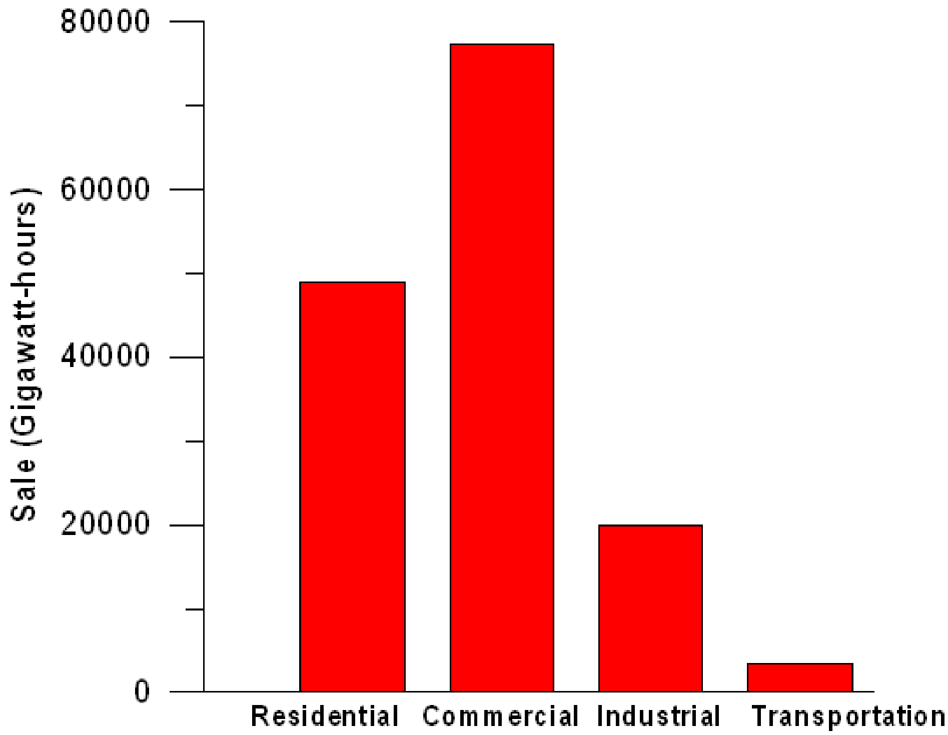
Net energy demand in New York differs from national demand in several respects:

- Residential net energy use accounts for 27% of total energy demand in New York, compared to 17% nationally.

- Commercial net energy use accounts for 24% of total energy demand in New York, compared to 13% nationally.
- Industrial net energy use accounts for 8% of total energy demand in New York, compared to 25% nationally.

The profile of electricity consumption confirms the trends noted in overall energy consumption. Figure 5-3 shows the NYS sales of electricity to ultimate consumers by sector for 2006 in terms of GWh.

Figure 5-3. Electricity Sales (GigaWatthours) - New York State, by Sector



As is the case with energy consumption generally in NY, a relatively small share of total electricity sales goes to the industrial sector. The decline in manufacturing in NY over the past 30 years in part explains the relatively small current share of energy consumption accounted for by industrial users. As the manufacturing base shrank, overall energy demand from the sector naturally declined.

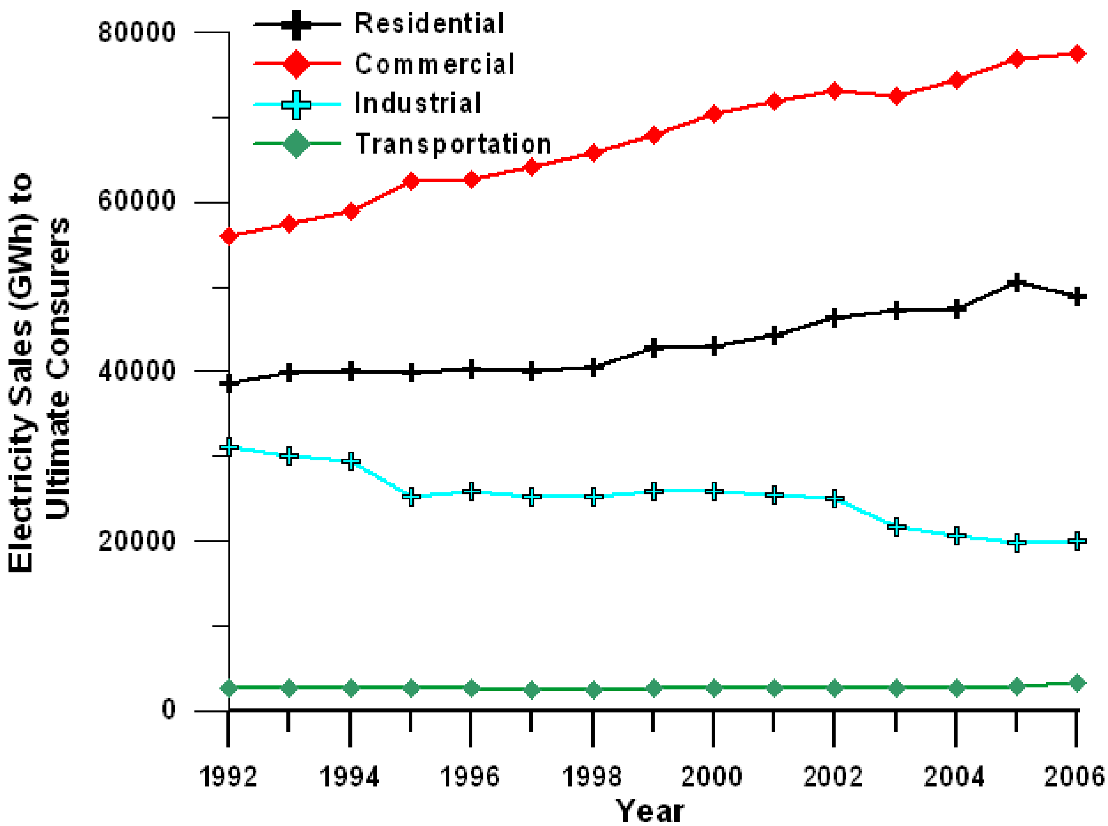
Table 5-2 and Figure 5-4 provide energy expenditure and usage figures for the commercial and industrial sectors in NY over the period 1992 to 2006, by fuel source. Industrial expenditures on energy declined from $4.4 billion to $3.3 billion, a 25% decline over 14 years. During the same period, the Onondaga/Oswego counties region lost approximately 40% of its manufacturing employment, so the slide in industrial energy expenditures for the region may well have been steeper than the statewide figures. Commercial expenditures increased by nearly 34% over the same period, mirroring the trend toward a more services-oriented economy.

By far, the largest expenditure in any year for either sector is for electricity. On average, electricity accounted for 69% of the commercial sector's expenditures on energy over the period and for 57% of the industrial sector's expenditures. Changes in relative prices for one source of energy or the other affected the year-to-year expenditures, but electricity's overall importance to these sectors' energy profiles is clear.

Table 5-2. New York State Energy Expenditure Estimates by Fuel Type and Sector in Constant 2006 Dollars, 1992-2006 (In Millions of Dollars)

Sector and Fuel Type	Year						
	1992	1997	2002	2003	2004	2005	2006
Commercial							
Coal	$14.1	$11.6	$2.2	$3.5	$7.2	$7.7	$10.0
Petroleum	1,216.8	921.3	950.0	1,473.0	1,737.7	2,101.8	2,007.7
Distillate	740.2	576.4	625.7	970.4	1,203.2	1,477.9	1,469.9
Residual	412.0	274.2	252.1	404.2	411.5	494.9	439.6
Kerosene	19.2	35.4	24.8	41.5	53.8	70.7	36.6
LPG	45.4	35.3	47.4	56.9	68.2	58.6	61.5
Natural Gas	1,795.3	2,614.8	2,605.9	3,197.6	3,874.5	3,633.8	3,115.3
Electricity	8,664.5	9,389.6	9,671.9	10,279.9	10,304.3	11,387.5	10,521.2
Total	**$11,690.6**	**$12,937.5**	**$13,230.0**	**$14,944.9**	**$15,922.7**	**$17,130.8**	**$15,654.3**
Industrial							
Coal	$178.4	$153.9	$97.2	$83.3	$81.5	$87.3	$113.8
Petroleum	311.4	247.4	224.8	322.0	375.6	562.8	615.7
Distillate	167.1	115.1	120.1	146.6	199.0	277.9	331.9
Residual	79.7	53.6	39.7	59.6	53.2	65.7	72.3
Kerosene	7.7	13.2	9.5	44.5	22.9	52.8	36.9
LPG	56.8	65.5	55.5	81.2	100.5	166.4	174.6
Natural Gas	1,051.7	1,309.7	599.9	653.0	681.1	830.9	840.5
Electricity	2,900.47	1,650.9	1,458.9	1,700.9	1,552.3	1,604.4	1,732.6
Total	**$4,441.9**	**$3,361.8**	**$2,380.9**	**$2,769.2**	**$2,690.5**	**$3,175.4**	**$3,302.7**
Source: NYSERDA, Patterns and Trends 2008.							

Figure 5-4. Historical Electricity Sales (GigaWatthours) to New York State Consumers



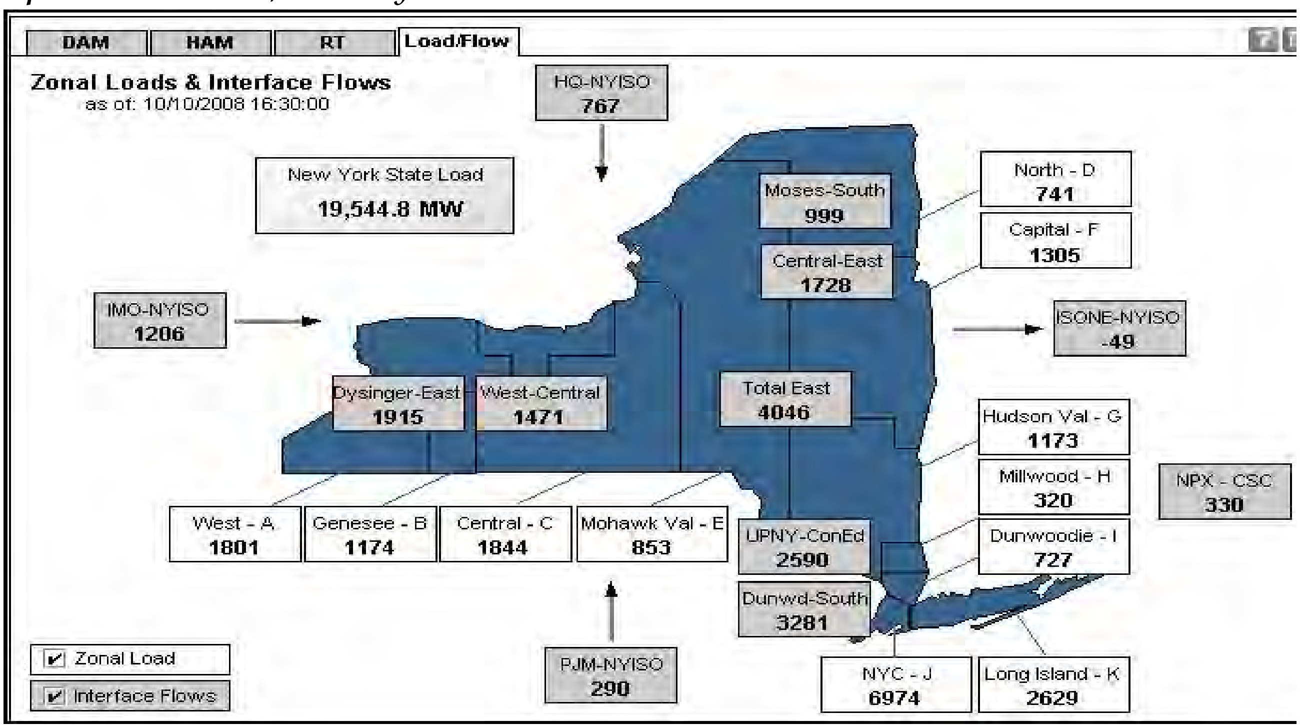
Without the influence of fluctuating energy source prices, the increases and decreases in sheer demand for electricity are more easily visualized. Commercial purchases increased by 38% over the period while industrial purchases declined by 35%. By comparison, there was an overall 17% increase in sales of electricity to ultimate consumers, including residential users. The largest growth here was on the commercial side. This increase in demand has occurred in tandem with the growth in the service sector as it became a main source of employment and economic activity throughout the state, while the decline in industrial demand is likely rooted in the decline of manufacturing capacity in the state.

5.3 Energy Demand and Usage By Zone

5.3.1 Historic Energy Usage Patterns

In an effort to provide some sense of the regional demand for electricity, the map below (Figure 5-5) is reproduced from the NY Independent Systems Operators web site, www.nyiso.com.

Figure 5-5. Regional Electricity Demand - New York State. Source: NY Independent Systems Operators web site, www.nyiso.com



The Onondaga/Oswego area is part of a larger Central zone identified by the map. At the point in time identified by the map, total load for NY is put at 19,545 MW. The Central region accounts for approximately 10% of this total load. The NYC zone, by contrast, represents nearly 36% of the state's total electrical load. While this is only a snapshot of demand at this particular moment in time, a Friday afternoon in October, it sheds some light on how demand/consumption is allocated across the state.

More helpful in terms of identifying aggregate regional energy usage is the data in Table 5-3 showing historic energy use by zone for the past decade. The central region again accounts for approximately 10% of the electrical energy used in the state. In 2006, the Central Region (Region C) accounted for 16,838 GWh. Figure 5-6 shows selected data from Table 5-3.

Table 5-3. Historic Annual Energy Use by Zone[a]- GWh.

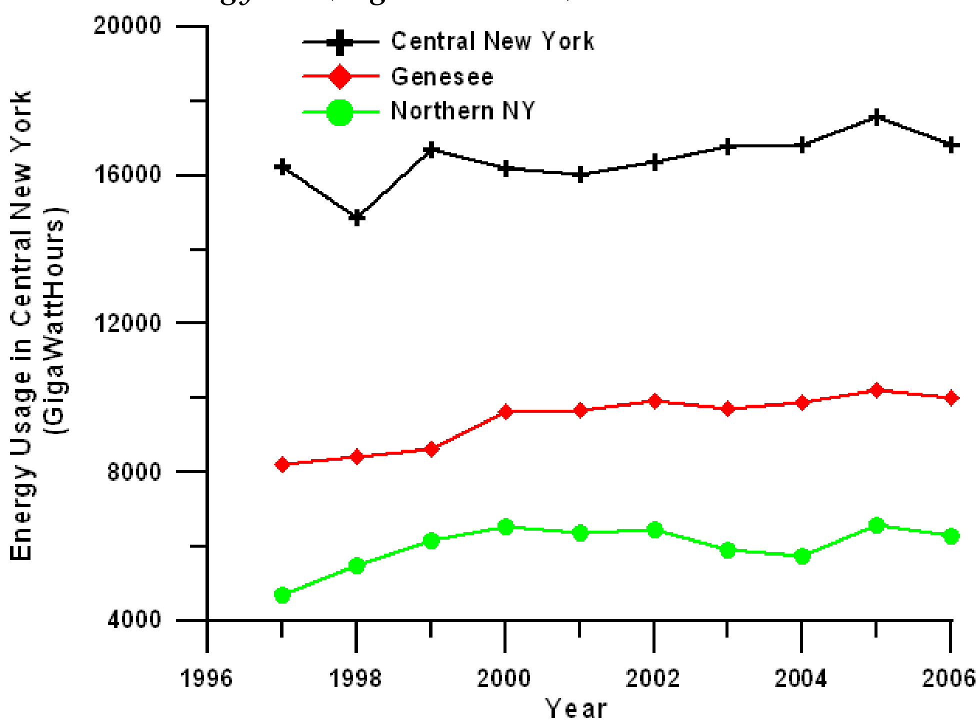
Year	A	B	C	D	E	F	G	H	I	J	K	NYCA[b]
1997	18,450	8,225	16,223	4,708	9,201	11,777	8,697	1,954	5,436	44,463	18,241	147,374
1998	18,207	8,408	14,878	5,488	9,545	11,781	8,956	1,958	5,702	46,076	18,856	149,855
1999	18,210	8,611	16,713	6,184	8,956	11,994	9,266	1,894	6,060	48,281	19,671	154,841
2000	16,785	9,635	16,182	6,527	8,182	11,398	9,304	1,952	5,929	49,183	20,072	155,140
2001	16,209	9,661	16,034	6,374	7,403	11,429	9,396	2,003	5,782	50,227	20,723	155,420
2002	16,355	9,935	16,356	6,450	7,116	11,302	9,970	2,162	5,962	51,356	21,544	158,507
2003	15,942	9,719	16,794	5,912	6,950	11,115	10,451	2,219	6,121	50,829	21,960	158,013
2004	16,102	9,888	16,825	5,758	7,101	11,161	10,696	2,188	6,216	52,073	22,203	160,211
2005	16,498	10,227	17,568	6,593	7,594	11,789	10,924	2,625	6,435	54,007	22,948	167,208
2006	15,998	10,003	16,839	6,289	7,339	11,337	10,417	2,461	6,274	53,096	22,185	162,237

Source: NYISO 2007 Load and Capacity Data

a. See Figure 5-5 for location and name of zones.

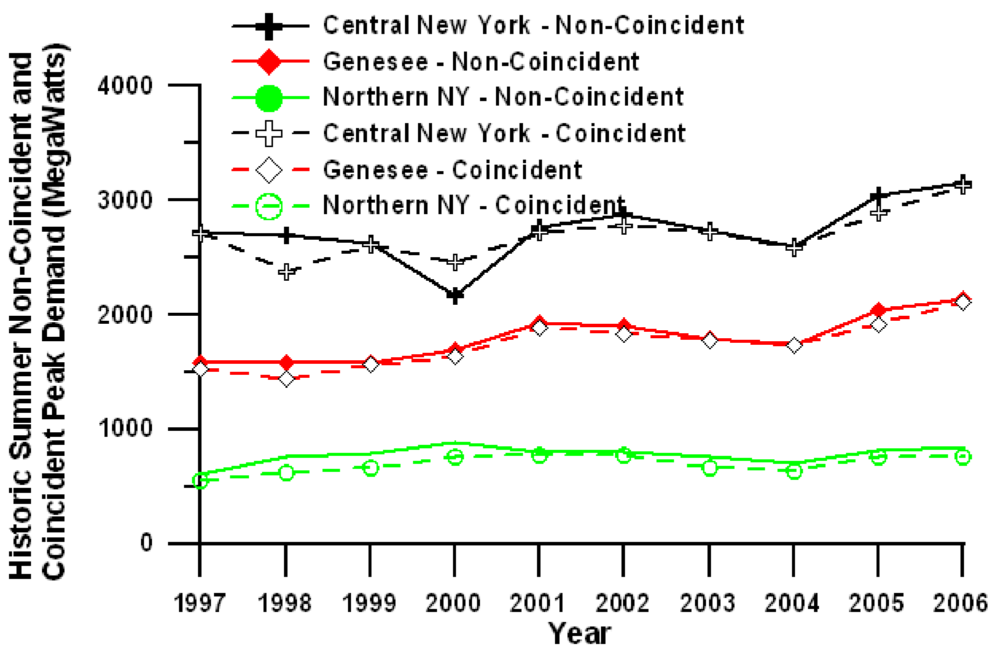
b. New York Control Area.

Figure 5-6. Historic Energy Use (GigaWattHours) in Three Central New York Zones



Information regarding aggregate seasonal demand for electricity has proven difficult to find. Since one might assume that a significant portion of summertime electricity usage is directed toward cooling needs, seasonal demand figures would be useful in arriving at an estimate for local cooling demand. Lacking this aggregate seasonal usage data, some inferences might be made from peak energy demand data. The figure below shows historical data on peak summer demand in three regions of the NY Control Area (NYCA). Figure 5-7 shows both non-coincident peak and coincident peak summertime values. Data for all regions can be found in the Appendix to this section.

Figure 5-7. Historic Coincident and Non-Coincident Peak Energy Demand (MegaWatts) in Three New York State Zones



Note that when two or more systems or subsystems place demand on another system at the same time, it is referred to as a coincident peak. The term is used to describe energy demand at any time when these parties' needs coincide with each other. It does not refer to a specific peak occurring during the time when both parties use the same energy source. Non-coincident peak is the individual or actual peak demands of each load in an electrical system oftentimes occurring at different hours of the day. It does not necessarily fall during system peak.

Coincident demand is the energy demand required by a given customer or class of customers during a particular time period. Coincident peak demand is the energy demand by that group during periods of peak system demand. Loosely speaking, it refers to demand among a group of customers that coincides with total demand on the system at that time. Residential demand at a time of peak industrial demand can be referred to as coincident peak demand, as can a particular plant's demand at a time of peak demand across the whole system.

A customer's coincident peak demand is usually calculated from meter readings taken at the time when the customer's demand is likely to be highest. Their non-coincident peak demand would be calculated using several readings taken at different times to determine what their actual peak demand periods may be. A more sophisticated type of meter is required to calculate non-coincident demand, but it does not necessarily produce a better result for the utility or the customer. An energy provider may care more about demand at a given time when total customer demand is highest than they care about the peak demand of a given customer during other times.

While still representing nearly 10% of total demand in the NY Control Area (NYCA), the Central region demanded over 3,000 MW at its summer peak in 2006. Two other peak periods occurred in 2005 and 2002 where peak demand spiked above average. As will be noted later in this section, 2002 and 2005 represented relatively “hot” years climatologically in terms of cooling degree days in the Syracuse area. 2006 represented a record high peak demand for the region. Although 2006 was not as warm overall as 2005 and 2002, according to total degree days recorded, its July cooling degree days were at similar elevated levels and possibly account for the spike.

5.3.2 Forecasts of Future Energy Usage

NYISO has compiled a forecast of annual energy needs for the state. Overall growth of 15% during the next 10 years is forecast, while the Central region is projected to grow at a slower 6% during the period (Figure 5-8).

NYISO has also issued forecast peak demand figures for the period 2007-2017 and these projections are shown in Figure 5-9. Growth of approximately 2% per year is anticipated over this period although spikes in demand, such as those in 2006, can easily interrupt the predictions.

Figure 5-8. Forecast of Energy Demand (MegaWatts) for Three New York State Zones

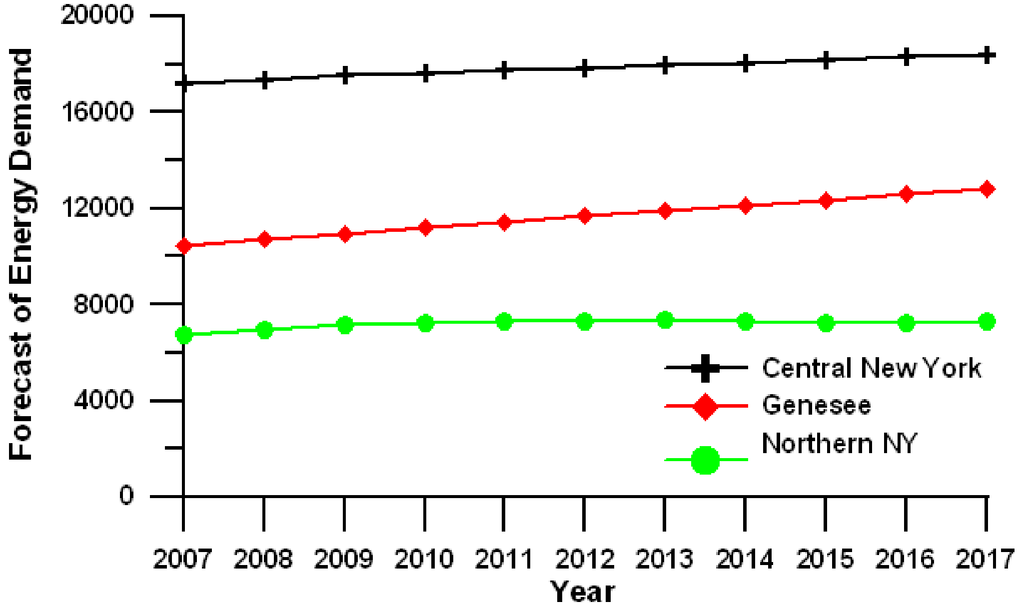
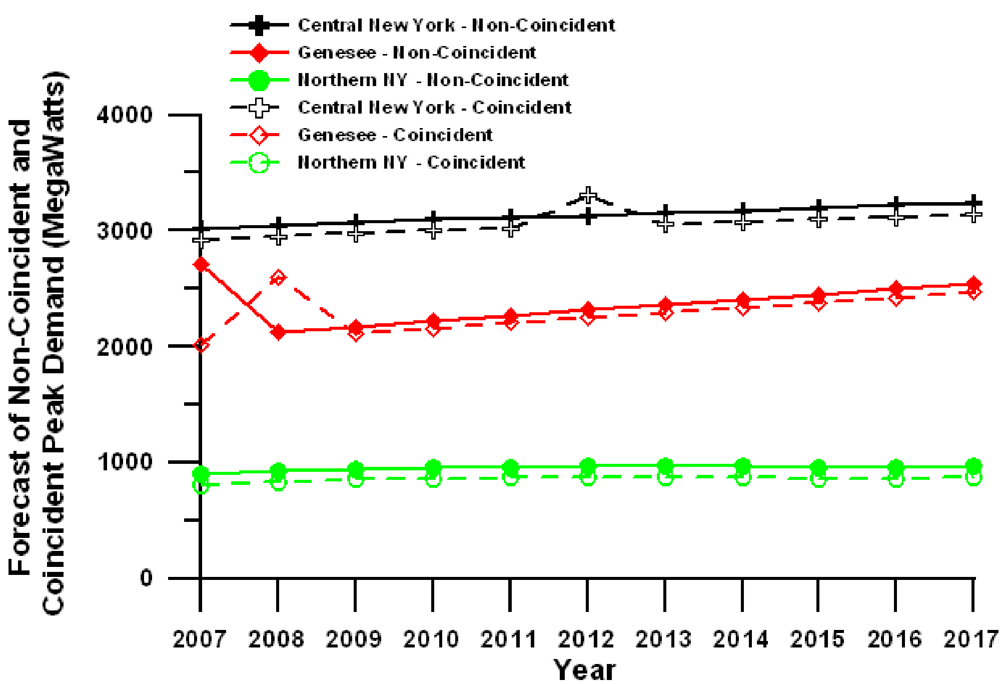


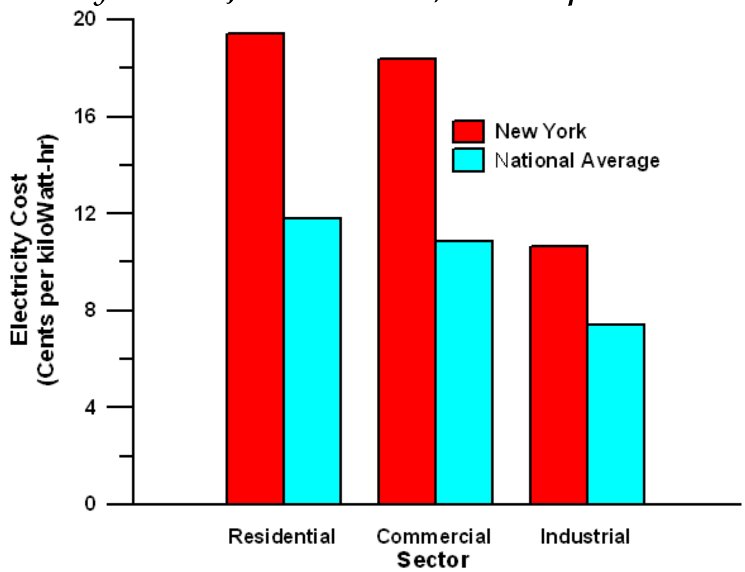
Figure 5-9. Forecast of Peak Coincident and Non-Coincident Energy Demand (MegaWatts) for Three New York State Zones



5.4 Energy Pricing in NY

According to the Energy Information Agency, NY electricity rates are significantly higher than national averages. This situation might be anticipated given that NY must purchase most of its fuels from outside the state and a significant fraction of its generated energy must also be imported.

Figure 5-10. Unit Electricity Costs - June 2008 data, in cents per kiloWatt-hour



Prices for most sources of energy were by and large stable during the 1990's. In particular, natural gas and electricity prices varied within a narrow range for much of the 1990's. All energy sources began to see larger upward price movements in the 2000's, especially natural gas, which has doubled in price from 1998 to 2006. Tables 5-7 and 5-8 in the Appendix to Section 5 trace this history across several energy sources for both the commercial and industrial sector.For the purposes of electrical cost comparison in this study we will use a common electrical cost of $0.12/kWh.

5.5 Section Summary

Most of the electricity used in New York State is generated from nuclear, hydropower, and natural gas energy sources. About 12% of the electricity used is imported from out of state (Figure 5-2). Energy usage is CNY is expected to show a modest increase over the next decade (Figures 5-8, 5-9). Electricity costs are higher in New York than national averages, with industrial users paying about $0.12 per kilowatt-hour (Figure 5-10).

6.0 Economic Opportunities Associated With District Cooling

6.1 Section Introduction

The Naturally Chilled Water Project (NCW) project as currently envisioned brings naturally chilled water into the Syracuse, NY Metro area. The NCW-supplied cooling would displace cooling currently or potentially supplied by mechanical means (chillers, air conditioning units, etc.) that are powered predominantly by electricity.

The economic development impacts of this proposal are threefold. At a macro level, the NCW- supplied cooling would supplant the need to consume the electricity required to mechanically cool air. As a result, this electricity would not need to be generated in the first instance and so the project would also displace the need for fuels to be consumed in generating the electricity. Such a result impacts the region's dependence on outside, often foreign, sources of energy and its allocation of resources on energy inputs.

According to NY State's 2002 Energy Plan “promoting cost-effective energy-efficiency improvements, indigenous and renewable energy sources,…stimulates in-State job creation…A secure and reliable energy supply will provide business with the confidence necessary to invest in New York. The increase in business profitability…that results from lower energy costs will further stimulate business investment…and employment growth within the State.” The economic leakage that results from NY's importation of energy is significant. While New York is the fourth-largest energy user of all the states, it's estimated that only about 13% of the State's total end-use energy requirements are provided by indigenous resources. This results in a nearly $40 billion annual outflow. The NCW would work to redress this imbalance and retain some of these energy expenditures in-State where the money would re-circulate, creating jobs and investments and at the same time would expand the range of locally available energy sources for end users.

A second, firm-level economic development impact of the project is the relative improvement in the energy consumption and expenditure profiles of existing commercial entities in the designated District Cooling zone. This economic development effect would derive from the presumably lower energy costs to the end-user for the delivery of space cooling as a result of the project and from cost reductions due to lower equipment maintenance and replacement costs since existing chilling and related equipment would operate less often and require less frequent replacement. Expenditures on energy for space cooling alone average 11.6% of total commercial end-use expenditures (EIA Annual Energy Outlook 2008). While it is true that regional and climate zone variations would likely lead to a lower percentage of total end-use expenditures in the Syracuse region, the localized presence of intense cooling users in a given cooling district and the above-average electricity costs in NYS (65% higher than national average - EIA, State Energy Data 2007) would still create the conditions for significant cost savings to commercial participants.

The third notable economic development effect of the project would be the creation of an economical, environmentally sustainable source of chilled water for space cooling and process cooling purposes which might attract commercial and industrial users looking to expand or locate in the region. In this instance, the availability of a chilled water resource would be expected to induce economic activity by commercial users who devote a large portion of their energy budget on cooling because they are intense users of cooling for operational reasons and by industrial users who utilize chilled water for process cooling purposes and/or may be intense space cooling users because of environmental process considerations (ambient temperature/humidity).

The following review will focus on the latter two economic development impacts. The first section will develop a profile of the commercial consumer of space cooling derived from data assembled by the Energy Information Administration. Using this profile, an estimate of regional consumption of and expenditure on space cooling will be made in an attempt to quantify potential benefits. The second section will identify and characterize those commercial and manufacturing sectors that are known to be major consumers of cooling and/or of chilled water for the purpose noted previously above.

6.2 Commercial Building Use

A preliminary effort to review the relative energy needs and consumption patterns of commercial buildings will be helpful in developing a local profile. The energy consumption profile of users and potential users that this will allow us to develop will not only help in quantifying the project's benefits to the initial consumers participating in a chilled water cooling project but should also help in identifying the types of users that might be attracted to a chilled water system in Central New York.

6.3 End User Profile

In its 2003 Commercial Buildings Energy Consumption Survey (CBECS), the Energy Information Administration (http://www.eia.doe.gov/emeu/cbecs/contents.html) compiles energy consumption data from a sample of commercial buildings throughout the country. Estimates of commercial buildings' energy consumption and usage by major source of fuel, end-use and size of building, region and climate zone are derived from the survey as well as specific cooling usage and production information. Since such detailed information is not readily available for the potential participants in the CNY Chilled Water cooling project, these EIA averages combined with the information available on the existing commercial building stock in CNY may assist in the development of a preliminary evaluation of the economic benefit of the project to existing and prospective end users. Estimates derived from this exercise will also be useful in evaluating the attractiveness of chilled water cooling to prospective businesses by helping to determine which end-users would gain the most benefit from access to this resource and by quantifying some of the economic benefits the project might offer to these users.

The EIA survey covers buildings that are “commercial”, that is, neither residential, manufacturing/industrial nor agricultural. The survey is based on a sample of 5,215 buildings across the country which were statistically sampled and then weighted to represent the entire stock of commercial buildings in the U.S. The estimates are divided into three sections: building characteristics; consumption and expenditures and end-use consumption.

6.4 Building Characteristics:

CBECS estimates that there were 4,859M commercial buildings in the US in 2003. Of those, 761M (~16%) were located in the Northeast (New England and Mid-Atlantic, which includes NY, PA and NJ). Some important characteristics of these buildings are summarized below:

- 46% of the commercial buildings in the Northeast are in the same climate zone as Syracuse. Syracuse is identified as lying within Zone 1, a climatic division in which the 30-year average shows fewer than 2,000 cooling degree days (CDD) and more than 7,000 heating degree days (HDD) per year.*
- Only 12.2% of the buildings contained 25,000 s.f. or more floor space. Nearly 50% of the buildings were 5,000 s.f. or less.

- 62% of the buildings were built before 1970 while only 4% were built after 2000.
- Building end-uses were widely distributed. The most prominent uses were offices - 20%; retail - 15%; service - 13%; warehouse - 9%; and public assembly - 8%.

6.5 Energy Consumption and Expenditure

In order to evaluate the relative utility of chilled water cooling, its potential to reduce overall energy consumption and cost needs to be assessed against the needs of end-users. Buildings that tend to consume above-average amounts of energy or that expend disproportionate amounts of money on purchasing energy would be more eager customers than those for whom these are less significant concerns. The distinctions may be based on the buildings end-use, size, age or physical location. This section will look at some of these distinctions and how they impact a commercial building's energy consumption profile.

Energy usage and expenditures on energy are important issues for most businesses in the Northeast and in the CNY region in particular, primarily because of the long heating season. According to the CBECS, commercial buildings in the Northeast consume 1,396 trillion Btu's annually and 99.8 thousand Btu's p.s.f., the highest energy intensity of all regions surveyed (the West was lowest at 82.9 thousand Btu p.s.f.). Commercial users spent $24,395 million on all major fuel sources and this broke out to $17.47 per million Btu's and $1.74 p.s.f., again the highest rate of all regions.

In terms of overall energy use, buildings in the 50,000 - 200,000 s.f. range are the largest consumers. Buildings whose principal activities are office, education and mercantile are the three largest end-users. Total energy usage generally declines as the building age decreases, although buildings built prior to 1920 appear to consume less energy than more contemporary buildings. Buildings in Climate Zone 1, where the CNY region is located by the CBECS, has the lowest overall consumption of the three zones represented in the Northeast region (15% of total Btus, 18% of total floor space). Most of these consumption patterns are in line with the relative presence of these buildings in the overall population of structures surveyed.

6.5.1 Energy Intensity

Energy intensity (1,000 Btus per square foot) seems well correlated with gross energy usage among the various groupings with one exception - the health care sector. While consuming 8% of total energy, this grouping represents only 4% of the total floor space. It's energy intensity is quite high at 212.2 thousand Btu per s.f. The next most intensive users are the education and office sectors whose intensities are less than half the health sector amount. Possible reasons for this disproportionate consumption pattern would be the use of energy-hungry equipment and the 24-hour nature of operations at these facilities, among other factors.

6.5.2 Energy Expenditures:

Approximately $24 billion was spent on all fuels and offices spent slightly more than a quarter of this amount, despite representing only 22% of all floor space. Another large consumer of energy was the retail sector which spent $3.9 billion, about 16% of the total while representing 12% of total floor space. The retail sector also spent the most per thousand Btu of all the sectors. The health care sector was a relatively minor player in this measurement overall as total square footage in this sector was comparatively small, although it again showed its intensive use of energy, spending $2.82 per square foot - considerably higher than the $2.27. and $2.07 spent per square foot by the much larger retail and office sectors, respectively.

6.5.2.a Size and Age of Buildings:

Expenditures on energy by building size and age followed patterns similar to those observed in energy usage within those groupings. Buildings in the 1,000 - 5,000 s.f. range expended more per square foot on energy than larger buildings. Per square foot expenditures declined as building size increased above the 50,000 s.f mark, possibly reflective of better rates available to larger users or and/or the need for better efficiencies in larger buildings. As noted earlier, older buildings tended to use less energy and use it less intensely than newer buildings. On the expenditure side, they tended to pay less per million Btus and spend less per square foot than newer buildings. This may have to do with the end-use profiles of these buildings as well as differentiated energy rates applicable to them.

6.5.2.b Climate and Geography

Somewhat surprising is the lower overall energy consumption and expenditures in the climate zone that includes the CNY region. According to the CBECS data, Northeastern commercial buildings in Zone 1, those with 2,000 or fewer cooling degree days and 7,000 or more heating degree days, utilized 15% of total fuel consumption (213 trillion Btus) while representing 18% of total floor space in the survey. Energy intensity in Zone 1 buildings, as measured in thousands of Btus per square foot, was nearly 18% lower than in the next warmest climatic zone. Likewise major fuel expenditures in Zone 1 are reported to be lower per square foot than in other climate zones in the Northeast. Zone 1 per square foot expenditures are over 11% lower than the next warmest Northeastern climatic region although Zone 1 expenditures on fuel, on a per million Btu's basis, is higher than other climatic zones in the region (exceeding Zone 2 by 8%). Part of the reason for this apparent discrepancy may be the greater reliance on cheaper natural gas for heating in this climatic zone. Another may be that the necessity of advanced weatherization in this Zone has rendered buildings more efficient users of energy. Importantly, overall energy consumption may well be depressed in this part of the Northeast owing to stagnating or declining economic conditions as well.

On a national level, these lower energy consumption, intensity and expenditure rates stand in even sharper contrast. Especially in comparison to parts of the country where one assumes a greater energy demand for cooling (as well as faster economic growth), overall energy consumption and expenditures on energy are noticeably greater than in the Northeast.

Over 6,523 trillion Btus of energy were consumed by commercial buildings in the United States in 2003. Nearly 55% of that energy was produced by electricity, 32% from natural gas and nearly 10% from District Heat. About $108 billion in total was spent on this energy. The South consumed more than a third of that energy (34%) followed by the Midwest (28%) and the Northeast (21%). In the South, over 68% of the energy consumed was generated by electricity. In comparison, in the Northeast, only 42% of total energy consumed was generated by electricity while 33% came from natural gas and approximately 13% and 12% were derived from fuel oil and district heat, respectively. The higher than average use of electricity in the South likely stems from the greater prevalence of cooling which is predominantly generated from electricity (approximately 99% according to CBECS - Table B30). The Midwest also consumes more energy overall than the Northeast. This may be partly explained by the fact that a larger proportion of its region is in climatic Zone 1 and may therefore have higher heating demands.

The relative cost of this energy to each region is interesting. The South depends on electricity for 68% of its energy needs and spends 83% of its energy dollars on it. The Northeast derives 42% of its total energy from electricity yet spends over 69% of its expenditures on energy for it. Of course, the means of generating electricity and consequently the cost to the end user can differ substantially from region to region. Whatever the cause of the discrepancy between the use and expense of electricity, it is clear that although the Northeast is less reliant on cooling and uses less electricity-generated energy because of this, overall electricity cost is important in the region, so cost reductions for this form of energy would be welcome from any quarter.

6.5.3 End Use

The comparative amounts of energy that commercial buildings use to power their various operations (heating, cooling, lighting, etc.) is important to know in order to assess the relative importance of cooling to a specific group of end users.

The EIA tracks energy use and expenditures for nine specific end-use categories: space heating, cooling, ventilation, water heating, lighting, cooking, refrigeration, office equipment and computers. The CBECS Glossary defines cooling as “The conditioning of air in a room for human comfort by a refrigeration unit (such as an air conditioner or heat pump) or by a central cooling or district cooling system that circulates chilled water. Use of fans or blowers by themselves without chilled air or water is not included in this definition of air conditioning.” The Glossary further defines ventilation as “The circulation of air through a building to provide fresh air to the occupants and to deliver heating and cooling to the occupied spaces.”

While there are two separate energy uses involved in delivering cooled air, this discussion focuses on the energy expended on cooling the air rather than on the whole air conditioning system. A main goal here is to determine the incremental consumption and expenditure benefits of a chilled water-based system. Since a ventilation system of essentially the same energy consumption profile would still be required to deliver the cooled air produced by a chilled water system as by any other means, the energy and money expended to operate the ventilation component is disregarded.

6.5.3.a How much energy is consumed by cooling?

Table 21-1 summarizes consumption by all buildings by end use for all major fuels. A total of 6,523 trillion Btus were consumed by commercial buildings. Approximately 8% of that (516tBtus) was consumed in producing cooling. The largest usage was space heating (36%) followed by lighting (21%). Excluding the "other" category, cooling is the third largest end use for the energy consumed by commercial buildings, although energy consumption for cooling is significantly less than consumption for lighting.

Table 6-1.Major Fuel Source Consumption by End Use for All Buildings

	Total Fuel Consumption (trillion Btus)									
	Total	Space Heating	Cooling	Ventilation	Water Heating	Lighting	Cooking	Refrigeration	Office Equipment	Other
All Buildings	6,523	2,365	516	436	501	1,340	190	381	255	569
Building Floorspace (ft^2)										
1,001 - 5,000	685	213	46	18	49	96	49	138	20	56
5,001 - 10,000	563	212	39	18	43	95	37	57	16	46
10,001 - 25,000	899	357	57	52	51	184	29	57	30	83
25,001 - 50,000	742	281	63	55	60	140	16	37	24	66
50,001 - 100,000	913	325	79	78	67	202	17	35	27	83
100,001 - 200,000	1,064	399	84	91	81	234	11	30	33	89
200,001 - 500,000	751	286	58	56	69	170	14	10	28	61
Over 500,000	906	292	91	67	81	220	18	19	25	85
Principal Building Activity										
Education	820	389	79	83	57	113	8	16	36	39
Food Sales	251	36	12	7	4	46	11	119	4	11
Food Service	427	71	29	24	67	42	105	70	4	16
Health Care	594	223	44	42	95	105	11	8	14	51
Inpatient	475	175	35	38	92	76	11	4	9	34
Outpatient	119	48	9	4	3	28	<1	4	5	17
Retail (Other than Malls)	319	107	25	16	5	111	3	22	7	24
Enclosed and Strip Malls	702	162	85	51	53	197	24	27	13	91
Office	1,134	400	109	63	4	27	3	9		26

The EIA reports that out of a total commercial building electricity consumption of 3,559 trillion Btus, 481 tBtu (14%) were consumed by cooling. In the Northeast, the amount of energy consumed to produce cooling was significantly lower. There, out of the total 587 tBtus consumed, only 43 tBtus (7.3%) were used for cooling. In climate Zone 1, 468 tBtus were consumed and 26 tBtus (5.5%) were used to produce cooling. So in the region and climate zone most like Central NY, the energy “budget” for cooling purposes is comparatively modest. In the Northeast and Zone 1, as well as in the rest of the country, the biggest draw on electricity is for lighting, 38% of total consumption nationally and 41% in the Northeast.

On a kWh basis, the EIA found identical patterns. 1,043 Billion kWh were consumed by commercial buildings with 13.5% going toward cooling. In the Northeast, 172 bkWh were consumed with 7.5% going toward cooling. In climate Zone 1, 137 bkWh were consumed with 6% used to produce cooling. Again, the amount of energy expended on producing cooling in the Northeast and in climate Zone 1 is not negligible but it is small relative to other uses. Lighting, ventilation and refrigeration were the three largest end uses covered by the survey.

6.5.4 Summary

Some of the specific cooling information for the Northeastern region buildings is summarized below:

- Of the buildings that used cooling, 25% of the buildings cooled between 1-50% of their floor space, 13% cooled 51-99% of their floor space and 33% cooled 100%. 29% of the commercial buildings in the Northeast had no cooling.
- Of the buildings built before 1980 (529,000 or nearly three-quarters of all buildings in the Northeast), 22% have undergone HVAC equipment upgrades since 1980.
- 37% replaced their main cooling equipment since 1990.

Various types of cooling equipment are used:

- 28% used residential type air conditioning
- 8% used heat pumps
- 25% used individual air conditioning units (compared to 16% nationally)
- 1% had a central chiller
- 28% had packaged air conditioning units
- 1% utilized a district chilled water system

According to EIA, 99% of buildings that have cooling use electricity as the main energy source to generate that cooling. Other sources include natural gas (0.5%) and district chilled water (0.9%). These percentages seem to pertain to buildings with cooling across all regions.

6.6 Onondaga County/City of Syracuse Commercial Building Profile

While specific building-related data on cooling is not available on a regional or climate zone basis, much less on a local basis, a sense of the usage and importance of cooling in CNY can be estimated by applying some of the information derived from the CBECS to the known distribution of buildings in the region or City. A first step would be a review of the information on the building stock that exists in the City of Syracuse and Onondaga County.

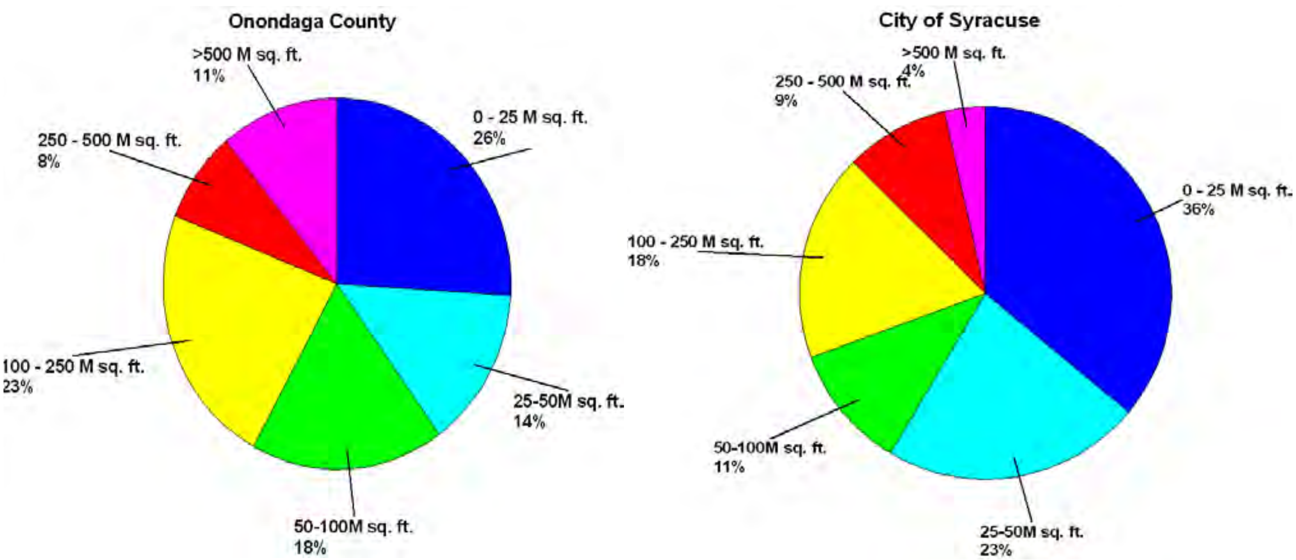
Information on building size and end-use activities was obtained from the property tax records of Onondaga County and the City of Syracuse. It's important to note that these databases include buildings designated as manufacturing facilities whereas the CBECS data just reviewed does not.

The total commercial square footage in the County is approximately 84 million (M) square feet (s.f.). In the City of Syracuse, the total commercial square footage is estimated to be 43M s.f.

In terms of the distribution of buildings by size in each jurisdiction, the breakdown by square footage is differs between the City and County. The county distribution is skewed toward larger buildings as might be expected. Buildings under 25M s.f. account for 26% of the County's total square footage while they account for 40% of the total square footage in the City of Syracuse.

The figures below show the population of buildings by size. In both jurisdictions, the dominant building size is 25M s.f. or less. The actual average size of these buildings is between 5 and 6M s.f.

Figure 6-1. Buildings bysize (ft^2, sq.ft.) in Onondaga County (left) and Syracuse (right).



While the City has many neighborhoods that include commercial buildings of all types, the dispersion of the County's commercial buildings over a larger geographic area bears some additional analysis.

Commercial buildings are dispersed among the various towns but a significant concentration exists in the Town of Dewitt and, to a lesser extent, the Towns of Clay and Salina. While the City has a commercial concentration in its Central Business District (CBD), the County can be thought to have a similar densities in the Town of Dewitt and in the Towns of Salina and Clay. The concentration of commercial activity in these locations may make them more appropriate destinations for a Chilled Water-based cooling district

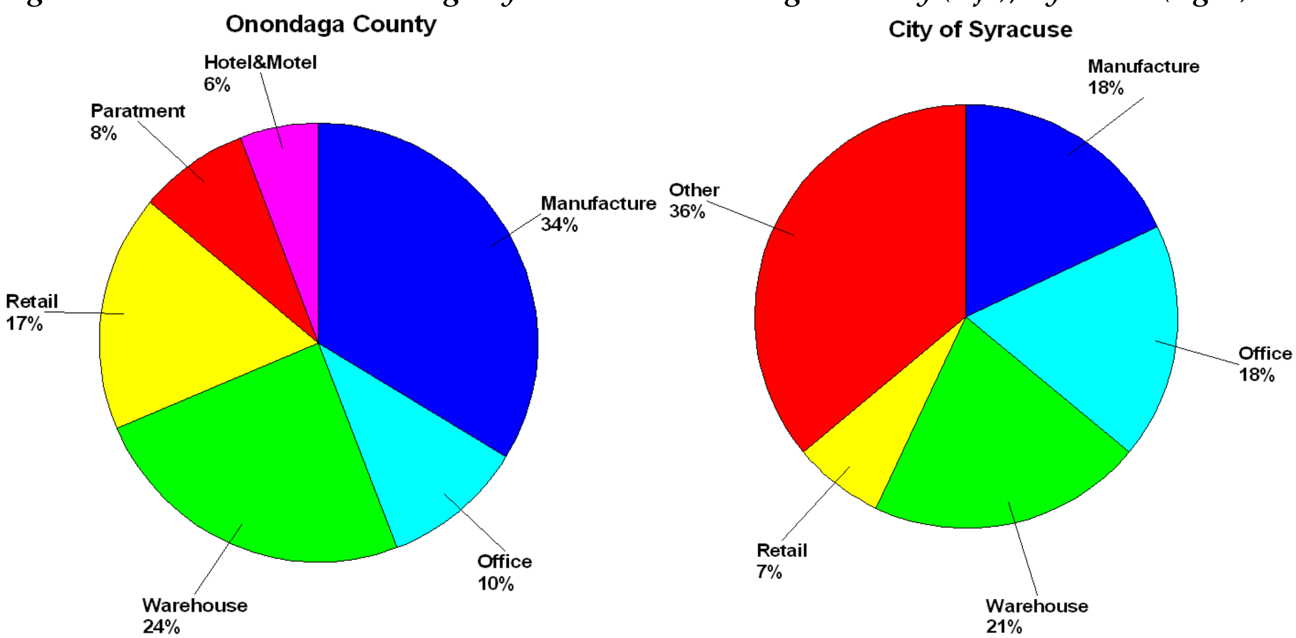
In terms of describing building distribution by end use, the classifications of buildings used by the County or City taxing department is used. Also, only buildings over 25M s.f. were analyzed. As noted earlier, the manufacturing classification is used in both databases but this is not an end-use considered in the CBECS.

Manufacturing is the largest distinct end use of commercial buildings in Onondaga County according to the data reviewed with approximately 23 million s.f. of space in that category. Warehouse and retail use are the next most prevalent activities representing about 12 million s.f. each. Offices account for slightly less than 5 million s.f. Not included in these totals are buildings that form the campus of Onondaga Community College in the Town of Onondaga.

OCC estimates that it campus comprises 1,011M s.f. of buildings, including 150M s.f. of residence halls.

As one might expect, the prevalence of office and "other" space is larger as one moves into the city. A traditional downtown core still exists for both retail and other commercial/institutional/governmental activities. A significant omission here, however, is the total square footage of buildings that comprise Syracuse University which that institution estimates to be over 9 million s.f. on its Main, Manley and South Campus sites. The size of individual buildings on campus was not available. Another noteworthy omission from the tax rolls would be LeMoyne College. Located outside the city center, the campus nonetheless contains approximately 700,000 s.f. of residential and academic buildings plus additional buildings totaling nearly 1 million s.f.

Figure 6-2. Commercial Buildings by End Use - Onondaga County (left), Syracuse (right).



Over 50% (3.8 M s.f.) of the "Other" category is comprised of parking garages. The balance is made up of a variety of commercial buildings that include auto dealers, banks and mixed use buildings.

Manufacturing facilities are generally larger structures than other commercial buildings so they tend to dominate as a percentage of total square footage, although light manufacturing operations can be found in smaller structures. Office and retail space might be relatively larger components of both the City and County's totals if smaller buildings had been included in the end-use analysis. Also, the end use stated on the property tax database may no longer be the relevant use of a particular building, e.g., this information may not have caught up with the conversion of a warehouse into lofts or a manufacturing facility into offices.

Total square footage of all commercial buildings in the County is estimated from the tax rolls and other public sources at approximately 84 M s.f. Subtracting the manufacturing component, there would be 61 M s.f. of commercial/institutional buildings in the County.

Total square footage of all commercial buildings in the City is estimated from the tax rolls and other public sources at approximately 43.7 M s.f. Subtracting the manufacturing component, would yield 40.3 M s.f. of commercial/institutional buildings in the City.

6.7 Section Summary

Energy consumption by commercial buildings in the Northeast is significant, primarily because of the relatively long heating season. The Northeast has the highest overall energy intensity in terms of tBtus per square foot. The region also has the highest energy expenditure intensity - $1.74 per square foot is spent on major fuels annually.

Cooling is an important energy end-use, primarily of electricity, throughout the country. Cooling as an end-use represents approximately 13% of total electricity usage nationwide. For the Northeast, cooling accounted for approximately 7.5% of the total kWh consumed in that region while buildings in Climate Zone 1 consumed only 6% of total kWh to produce space cooling. Electricity consumption in these areas is primarily to produce lighting (41% and 39%, respectively).

Nationwide, 78% of all commercial buildings are at least partially cooled. In the Northeast, 71% of all buildings had some cooling. This lower overall “share” for cooling supports the assertion that in the Northeast, cooling accounts for less than the national average of 13% of all electricity consumption. Additionally, the CBECS reports that the percentage of commercial buildings in the Northeast that are 100% cooled is 33%, a considerably smaller amount than found nationwide (43%). The percentage of buildings that have no cooling, 29% is notably greater than the national average of 22%.

So while the overall importance of cooling as an end-use of the region's energy “budget” is considerably less than is the case elsewhere in the nation, the disproportionate amount of regional resources that must be devoted to purchasing energy for all purposes makes any project that might result in a significant cost reduction in some major end-use component worth considering.

The City of Syracuse offers the concentration of commercial activity in its Central Business District (CBD). This area and the very proximate University Hill education/health complex of buildings would seem to offer the most logical client base for a district cooling project because of the economies of serving such as large base of buildings in a relatively small geographical area. An estimate specific to this extended Central Business District have already been done as part of this feasibility study.

The most intense users of cooling as identified in the foregoing data - health care, large retail and offices are concentrated in or near the CBD as well. The oldest buildings and therefore the ones most likely to benefit from the equipment savings of a cooling district are also most likely to be found in the City. If the distribution of buildings included fewer intense users, or newer buildings with less pressing equipment replacement requirements, the economics that pertain to the relatively less prominent cooling needs in this region might disadvantage the project. The necessary capital costs to undertake the project and the eventual potential energy cost savings might not be of a magnitude sufficient to warrant its pursuit.

The physical dispersal of buildings in the County would be a barrier to a wide delivery of cooling from the NCW project. There are several concentrations of commercial and industrial activity in the Town of DeWitt/East Syracuse and the Towns of Clay and Salina. The question would be whether the infrastructure could be economically built to service these areas as part of a larger system designed to support of cooling district in the CBD. Another important consideration is the combination of buildings in these concentrations - does it include intense cooling users so as to make the provision of the chilled water resource a sufficiently desirable asset given the overall demands on the users' energy budgets for heating and lighting? Lacking appropriate data on the cooling needs of manufacturers also hampers efforts to fully determine the utility of chilled water to such locations as well.

7.0 Naturally Chilled Water as an Economic Development Tool

7.1 Naturally Chilled Water as a CNY Business Attraction

The NCW project brings several potential benefits to the region from an economic development attraction perspective: the possible lower energy costs associated with providing space cooling through a chilled water system; the environmentally more neutral effect of using such a system to cool large areas, and: the availability of large quantities of the naturally cooled chilled water itself.

In general, the data suggest that cooling per se is not a significant regional economic issue, presumably because of inherent climatic conditions that result in lower demand for cooling. For the average business, a lower cost or more abundantly available source of space cooling will not be a significant attractant alone. However, intense consumers of cooling or even specifically of chilled water for cooling or process cooling, may well be attracted to an abundant resource such as lake-sourced chilled water on a cost and availability basis. Several candidate industries are identified in this section.

7.2 Industries

The 2003 Commercial Buildings Energy Consumption Survey (CBECS), conducted by the Energy Information Administration (http://www.eia.doe.gov/emeu/cbecs/contents.html) identified which sorts of commercial buildings are the most intensive users of space cooling - health care, some large retail buildings, food service and offices. The most intense users tend to be buildings whose activities must be carried on continuously or at least for a larger portion of the day than traditional business hours. In commercial settings, extensive cooling might also be necessitated by the operation of significant numbers of heat-producing office or other equipment. And while many offices are only open during typical business hours, there are many office-based operations that are organized on shifts much like a manufacturer (e.g., call centers or service centers that must be open 24 hours a day, 7 days a week). Such businesses are likely to be the entities that contribute to the higher energy and cooling intensities of specific commercial building categories that have been reviewed to this point.

7.2.1 Data Centers: North American Industry Classification System (NAICS) 518210

The energy consumed by data center servers, cooling equipment and related infrastructure more than doubled in the US and worldwide between 2000 and 2005 according to an AMD-sponsored study. A jump in the number of servers deployed accounts for 90% of the additional power consumption. Demand for internet content is seen as the main driver. A recent EPA study on data center energy efficiency indicated that another doubling of consumption could occur between 2006 and 2011.

The AMD study estimated that the total electricity bill to operate data center servers and related infrastructure equipment in the US was $2.7 billion in 2005. US data center power consumption was equivalent to about five 1,000-megawatt power plants or five typical nuclear or coal power plants. Server centers consumed 0.6% of all electricity in the US in 2005 and if auxiliary equipment such as cooling and networking is included, that figure rises to 1.2%.

The data center segment is confronting a significant energy challenge as the demand for internet content in particular shows little sign of abating. Since a significant portion of the data center's energy bill is derived from the requirement to cool equipment, the industry should be responsive to an environment in which these costs could be contained or managed more effectively.

New York's State Energy Research and Development Authority (NYSERDA) recently announced that it will provide over $100 million through its Industrial and Process Efficiency Program to help data centers and manufacturers control their energy costs and improve their competitiveness. NY's stake in this sector is large. It has the second largest concentration of data centers in the nation. Their energy usage is huge - a recent study conducted by the Lawrence Berkeley National Laboratory found that NY data centers spend nearly $600 million annually on energy costs and predicted that this consumption could double within 5 years.

7.2.2 Business Support Centers/Call Centers: NAICS 5614/56142

Many support centers need to operate on an extended-day basis because they service numerous time zones or must provide 24 hour availability. As such, they consume more energy than a typical commercial building tenant and would require more comfort cooling to accommodate workers. Some centers may require additional cooling to maintain recommended temperatures for certain office equipment, such as computers and servers, that are in use during operations.

This sector has experienced growth as companies sought to outsource certain functions to save money. Many service centers/call centers are foreign based although there appears to be a small trend of these functions returning to domestic locations. The Syracuse-area has a good local representation in this sector and has been a popular location for these firms because of labor costs and labor availability.

Related to this sector in terms of its relative importance to the CNY economy and its use of large blocks of office space in the region in the financial services industry. This sector includes banks, investment firms and insurance companies.

7.2.3 Financial Services Industry: NAICS 522-525

The financial services industry in Central New York consists of insurance related companies (48%), banks and other credit providers (32%) and investments (18%). In addition to headquarters operations for several regional banks and insurance companies, many of these firms are back-office operations processing transactions and other business for larger national firms, attracted to CNY for the lower operating cost environment and the skilled workforce that results from this local cluster of talent.

These establishments can be relatively large (16 of them have 250 employees or more) and require significant office space. A considerable amount of office space in the Central Business District is devoted to this sector. Its presence in the market does and will continue to influence demand for energy, particularly cooling.

7.2.4 Industrial Cooling

In industrial applications, chilled water or another chilled liquid is pumped through process or laboratory equipment. Industrial chillers are used for controlled cooling of products, mechanisms and factory machinery in a wide range of industries. They are often used in the plastic industry in injection and blow molding, metal working cutting oils, welding equipment, diecasting and machine tooling, chemical processing, pharmaceutical formulation, food and beverage processing, paper and cement processing, vacuum systems, X-ray diffraction, power supplies and power generation stations, analytical equipment, semiconductors, compressed air and gas cooling. They are also used to cool high-heat specialized items such as MRI machines and lasers.

The chillers for industrial applications can be centralized, where each chiller serves multiple cooling needs, or decentralized where each application or machine has its own chiller. Each approach has its advantages. It is also possible to have a combination of both arrangements, especially if the cooling requirements are the same for some applications or points of use but not all. Decentralized chillers are usually small in size (cooling capacity), usually from 0.2 tons to 10 tons. Central chillers generally have capacities ranging from ten tons to hundreds or thousands of tons.

Chilled water is used to cool and dehumidify air in mid- to large-size commercial, industrial, and institutional facilities. Water chillers can be either water cooled, air-cooled, or evaporatively cooled. Water-cooled chillers incorporate the use of cooling towers which improve the chillers' thermodynamic effectiveness as compared to air-cooled chillers. Evaporatively cooled chillers offer efficiencies better than air cooled, but lower than water cooled. Water cooled chillers are typically intended for indoor installation and operation, and are cooled by a separate condenser water loop and connected to outdoor cooling towers to expel heat to the atmosphere.

Air Cooled and Evaporatively Cooled mechanical chillers are intended for outdoor installation and operation. Air cooled machines are directly cooled by ambient air being mechanically circulated directly through the machine's condenser coil to expel heat to the atmosphere. Evaporatively cooled machines are similar, except they implement a mist of water over the condenser coil to aid in condenser cooling, making the machine more efficient than a traditional air cooled machine. No remote cooling tower is typically required with either of these types of packaged air cooled or evaporatively cooled chillers.

Cold water readily available in nearby water bodies might be used directly for cooling, or to replace or supplement cooling towers. The Deep Lake Water Cooling System in Toronto, Canada, is an example (see Section 3). It dispensed with the need for mechanical chillers with a significant cut in carbon emissions and energy consumption. It uses cold lake water to cool city buildings via a district cooling system. The return water is used to warm the city's drinking water supply which is desirable in this cold climate. Whenever a chiller's heat rejection can be used for a productive purpose, in addition to the cooling function, very high thermal effectiveness is possible.

A wide range of industries could potentially make advantageous use of chilled water in their operational and process cooling applications. Specific cooling applications that could make use of chilled water to cool a process or an ingredient that is part of a manufactured product number in the hundreds. Based on their energy profiles, ongoing presence in the CNY economy or their relative attractiveness as industrial, such applications in particular industrial sectors are highlighted and described below. Where available, national and local information on the industries' size and economic impact is included.

7.2.4.a Concrete and Cement Production: NAICS 327310-390

Typically, these products are mixed into a batch that requires a particular amount of chilled water which is used to cool down the solution after production. Naturally chilled water would reduce the manufacturers' need to mechanically chill this water for the mixture.

Since most concrete and cement demand is met by local production capacity, owing to transportation cost barriers, this industry would not be a significant target for new economic development opportunities. Existing producers would, however, benefit from lower energy costs that could presumably be passed on to their customers in the construction industry.

7.2.4.b Food Industry: NAICS 311

There are a variety of chilled water based applications in this sector that range across various aspects of food processing and across specific sub-sectors of the industry. Pre-cooling prior to processing, chilled water washing of foods, batch cooling for mixing ingredients, cooling prior to packaging, and cold storage are all uses that consume significant energy and water resources. Breweries and wineries have process cooling applications as do industrial bakeries. In most cases heat from the processing equipment or from natural reactions within the production needs to be dissipated. Cooling may be accomplished through an external heat exchange process or through the injection of chilled water directly as an ingredient.

Food processing in general is a significant industrial sector and encompasses a variety of industries. Several of the largest food processing companies are headquartered in NYS. Cornell and Geneva Experimental agricultural programs could be leveraged to local advantage. There are certain locational issues critical to some segments of the food industry that mitigate for multiple, distributed facilities: regionally specific tastes and preferences, security concerns and freshness. If the market for the product is national market and there is no freshness issue, facility location is more likely to be in the central US in any event. In the CNY region, some regional infrastructure exists to support growth in this industry.

7.2.4.c Medical Technology and Laboratory Equipment

The health care medical industry has a wide range of applications that make use of chilled water. The technological advancement in health care equipment has led to more and more equipment requiring a chilled water source. Equipment that needs some type of chilled water cooling includes CT Scanners, MRIs, PET Scanners, Oncology Linear Accelerators and blood cooling systems. Cooling for this equipment can be provided by smaller, potable chillers but manufacturers also offer a variety of chiller equipment for the medical industry.

Laboratory research equipment such as electron microscopes, lasers, reaction vessels and sputtering systems also require chilled water cooling and are often serviced by small footprint, portable chillers but might also take advantage of larger chilling systems.

7.2.4.d Pharmaceuticals: NAICS 325412

Cooling water is a critical component in various phases of the pharmaceutical manufacturing process, from research and development, bulk manufacturing and packaging of the pharmaceuticals.

Batch cooling is frequently used in the pharmaceutical industry. Batch cooling involves the pre-chilling of water or other fluid to a specific temperature before the fluid is added to a mix. A chilled water system would be beneficial to use as the cooling agent in place of a mechanical chiller or as the chilled water itself which would require less energy to bring to the desired temperature. In a pharmaceutical application, chilled water is needed to facilitate crystallization of final products after a high temperature reaction. Other uses include:

- Cooling ointments before rolling and packaging
- Controlling the temperatures of the molding process that forms gelatin for capsules
- Heating and subsequent cooling of components of creams before they're mixed together
- Heating and cooling during sterilization of liquid pharmaceuticals

- Water used in the wet granulation process for tablet forming

7.2.4.e Plastics: NAICS 326111-199

Most molded products, whether injection molded, blow molded or vacuum formed (thermoformed) products are cooled by chilled water in mold cavities. The cooling time, which normally is the longest part of the total cycle time and the molding process, is an expensive and an important part of the manufacturing process. Lowering the chilled water temperature in the mold leads to a shorter cycle time.

Blow molded products are blown by compressed air and cooled by chilled water in mold cavities. Heat is transferred from the outside surface of the part to the mold surface. The internal surface (hollow) of the blow molded part remains at a much higher temperature during the mold cooling process. The variance in the outside and the inside surface temperature is what causes material stress. The wall thickness distribution is never equal in a blow molded part. The mold cooling is not equal on the mold surface either. Heat transfer from heavy parts of a blow molded product through a limited mold surface is not equal to that of thin walled parts through large surfaces. This in fact causes more material stress and distortion in blow molded products.

Humidity in the production area is also a control issue for many plastics manufacturers. Air conditioning equipment to cool the production area is required in most instances to achieve target humidities.

7.2.4.f Precision Machining: NAICS 332721

Most precision machining is now performed on Computer Numerically Controlled (CNC) machines or vertical machining centers. Most of these machines require regular and constant cooling to operate effectively and many rely of chilled water to accomplish this. Some examples include CNC welding, milling, plasma or laser cutting machines. Constant On laser cutters require a stable source of chilled water that is constantly flowing. Some industrial plasma cutting CNC devices require water circulated through a loop to cool the device to ensure proper operation.

7.2.4.g Semiconductors: NAICS 334413

Poly and metal-etch processing is part of semiconductor fabrication, and requires very precise process temperature control. Current industry processes widely use mechanical direct-expansion/chilled-water systems for cooling. A typical fabrication plant's poly and metal-etch processes alone require 50-60 tons of cooling to maintain process temperatures within ± 0.2 C. These systems are slow to respond to changing loads, mixing chilled water with hot water to provide the required process temperatures

A semiconductor cleanroom facility system is complicated, usually comprised of several sub-systems, such as a chilled water system, a make-up system, an exhaust air system, a compressed air system, a process cooling water (PCW) system, a nitrogen system, a vacuum system, and an ultra-pure water (UPW) system.

7.3 CNY's “Cluster Industries”

Another way of assessing potential fit for a relocating industry is through the examination of the region's “industrial infrastructure” as represented by “cluster” industries. Cluster industries are geographic concentrations of competing, complementary, or interdependent firms and industries that do business with each other and/or have common needs for talent, technology, and infrastructure.

The existence of cluster industries indicates a high concentration of workforce and management in particular fields and also that the needs of that industry sector were being met by these and other infrastructural components necessary for this industry sectors vitality in the region.

The Empire State Development Corporation (ESDC) has identified 16 industry clusters in NYS and has catalogued how the clusters rank in terms of total employment, total wages, average wage and location quotient for the State as a whole and for the ten labor market regions, including Central NY. A location quotient (LQ) is a measure of concentration of industry employment locally to that of the US. If the LQ number is greater than 1, then the region's labor market contains a higher concentration of jobs in that industry sector relative to the US. It also is assumed that industries with an LQ greater than 1 produce more than the local market needs and are therefore “net wealth generators” for the region, that is they “export” their goods and services outside the region.

The top five CNY clusters ranked by employment are:

- Front Office & Producer Services (16,500)
- Distribution (15,090)

- Industrial Machinery & Services (13,460)
- Financial Services (13,080)
- Travel & Tourism (12,980)

Front Office & Producer Services and Financial Services rank high in terms of the total employment locally. They are also industry segments that operate primarily in large commercial office settings which require significant cooling, as noted in the first section of this report. Industrial machinery and services would include the precision machining sector noted earlier for its extensive use of chilled water in its fabrication processes. The presence of significant employment clusters in these sectors is also a prerequisite for any kind of attraction outreach to similar businesses.

The top five CNY clusters ranked by total wages are: (millions of dollars) are:

- Front Office & Producer Services ($962.8)
- Industrial Machinery & Services ($817.2)
- Financial Services ($767.2)
- Distribution ($701.4)
- Materials Processing ($348.7)

The same sectors contribute economically to the region in terms of the considerable wage income they provide. The addition of the materials processing sector, another high potential user of process chilled water, is notable. The retention of industries that are already significant players in the local economy is a major goal of any economic development strategy as is identifying ways to assist their expansion efforts.

The top five CNY clusters ranked by Location Quotient (private sector jobs only) are:

- Industrial Machinery & Services (1.53)
- Biomedical (1.52)
- Forest Products (1.21)
- Materials Processing (1.14)
- Distribution (1.07)

These clusters represent industries which have a proportionally higher representation in Central New York than in the rest of the nation. These are industries that have tended to locate in the area because off some intrinsic attribute in the region such as location, natural resources, workforce availability, etc. Their presence indicates a potential competitive advantage for the region in attracting similar industries.

The industries clustered based on location quotient correlate well with the types of businesses that might use a chilled water resource for space and industrial cooling. With the exception of the distribution sector, all of the industries in this group could benefit in some manner from a naturally chilled water resource for either space cooling or industrial process cooling or both.

- Offices and Financial Services: Depending upon the particular activity, offices can be one of the most cooling intensive consumers in the commercial sector
- Industrial machinery and Services: As noted earlier, much industrial cooling is dedicated to keeping machinery and equipment within certain operating temperatures. CNC machines and machining centers both rely on it to maintain efficient production.
- Materials Processing: This is a broad sector that encompasses industries in chemical, primary metals, petroleum and concrete manufacturing. The plastics and concrete manufacturing industries are well represented in CNY and are substantial users of chilled water for process cooling
- Biomedical: As noted earlier, water and chilled water are important inputs in many areas of the biomedical sector, from the cooling of research equipment to the manufacture of certain pharmaceuticals.
- Forest Products: This is a considerably energy and water intensive industry that might benefit from the development of a chilled water system. Pulp and paper manufacturers in particular are large users of water and might benefit if capacity is increased.

7.4 Section Summary

The potential for NCW to positively influence economic development in the region is noteworthy. The foregoing review of intensive cooling users in commercial and industrial settings identified numerous existing business sectors in CNY that would benefit from the availability of a naturally chilled water resource. A review of industry clusters in the region indicated that most industries which might be attracted to CNY for its favorable "industrial infrastructure" would also stand to gain from the existence of a chilled water resource. Finally, a review of several of the sectors that local economic development believe to be realistic targets for attraction efforts shows that the advantages offered by a chilled water cooling resource seem to dovetail well with those target industries' needs.

Another significant economic development impact might be found in the boost to the competitiveness of local manufacturing. A large number of the industrial process cooling applications identified in this section are concentrated in industries with a significant presence in Central New York. The potential energy and equipment overhead cost savings that a chilled water system could convey to this sector could substantially alter their competitive position relative to other regional, national and even international competitors.

Absent a specific cost for cooling that results from there being a chilled water cooling district in the central business district, it is difficult to gauge the potential energy saving that might be associated with its implementation for office-based firms such as call centers and back-office operations. As these details become clearer, it should be possible to quantify the benefits of space cooled by a chilled water system. While backup mechanical chillers would likely be required, maintenance costs would be considerably lower and should be factored into any assumptions on savings.

In the case of industrial users, the replacement of mechanical chillers stands to be the biggest advantage of using chilled water as these machines must be run year round during the production process. Again, an estimate of a cost to provide chilled water to the facility would enable a calculation of the savings on the electricity that would otherwise be purchased to run the mechanical chillers for a specified volume of water used. As with space cooling applications, backup mechanical chillers would be needed to ensure uninterrupted production but lifetime maintenance costs would be lower as would be the costs associated with replacement of these units.

8.0 Identification of Potential Customers for Naturally Chilled Water

8.1 Section Introduction

To refine the picture of the current local economic environment, it will be useful to provide some detail on the nature of the region's employers and to identify the larger employers and where they are located within the region. A review of the local business community as a population of establishments with varying work force sizes and linkages to larger industrial sectors is presented.

8.2 Identification and Description of Industrial Sectors

8.2.1 Classification, Number, and Size of Local Economic Entities

Table 8-1 categorizes business establishments according to the size of their work force and their classification by two-digit North American Industry Classification System (NAICS) codes. The information is derived from County Business Patterns 2006 and covers establishments in Onondaga and Oswego Counties.

Table 8-1. Number of Establishments by Employment-Size Class - Onondaga and Oswego Counties

Industry Code Description	Total Estab-lishments	1 to 4	5 to 9	10 to 19	20 to 49	50 to 99	>99
Total	**14,163**	**7,086**	**2,819**	**2,024**	**1,398**	**486**	**350**
Forestry, fishing, hunting, and agriculture support	12	9	2	1	0	0	0
Mining	10	3	0	5	2	0	0
Utilities	40	9	6	9	6	3	7
Construction	1,421	920	222	140	105	24	10
Manufacturing	578	192	91	87	114	36	58
Wholesale trade	922	420	191	156	94	36	25
Retail trade	2,178	800	599	390	248	87	54

Table 8-1. Number of Establishments by Employment-Size Class - Onondaga and Oswego Counties (Continued)

Industry Code Description	Total Estab-lishments	1 to 4	5 to 9	10 to 19	20 to 49	50 to 99	>99
Transportation & warehousing	350	155	45	48	56	26	20
Information	272	127	51	37	33	11	13
Finance and insurance	858	423	233	111	44	29	18
Real estate/rental/leasing	718	482	130	68	30	6	2
Professional/scientific/technical services	1,357	854	205	159	94	31	14
Management of companies and enterprises	85	32	13	12	14	5	9
Administration, support, waste management, remediation services	670	387	85	75	66	27	30
Educational services	128	66	20	18	11	8	5
Health care and social assistance	1,461	598	315	281	159	54	54
Arts, entertainment and recreation	260	157	45	31	18	7	2
Accommodation and food services	1,350	584	202	239	235	75	15
Other services (except public administration)	1,467	844	364	155	69	21	14
Unclassified establishments	26	24	0	2	0	0	0
Percent size class		50.0%	19.9%	14.3%	9.9%	3.4%	2.5%
Source: U.S. Census Bureau, County Business Patterns, 2006.							

As can be seen from the table, most business establishments in the region are small with 50% of the 14,000+ businesses reporting 1 to 4 employees. Twenty percent have 5 to 9, 14% are in the 10 to 19-employee range, while 10% report between 20 and 49 employees. Only 2.5% of firms reported having 100 or more employees. Of these larger employers, approximately 17% were manufacturers, 15% were retailers, and 15% were health care/social assistance entities. The other significant employer sector, the Finance, Insurance and Real Estate Industries (FIRE), tended toward smaller establishment sizes with nearly 60% of its businesses in the 1- to 4-employee size category. Only 1% of the companies in this industry reported employing more than 100 workers.

Another important measure of the impact of specific industries on the local economy is their relative contribution to the region's payroll. Table 8-2 shows the annual payroll figures for various establishments by sector, comparable to the listing of industries used above.

Table 8-2. Payroll by Employment Classification- Onondaga and Oswego Counties

Industry Code Description	Payroll ($1,000)			
	Annual	**Total Estab-lishments**	**Percent of Total Estab-lishments**	**Percent of Total Payroll**
Total	**$8,732,635**	**14,163**		
Forestry, fishing, hunting, and agri-culture support	No data	12	0.08	No data
Mining	No data	10	0.07	No data
Utilities	$411,854	40	0.28	4.72
Construction	$541,186	1,421	10.03	6.20
Manufacturing	$1,457,650	578	4.08	16.69
Wholesale trade	$655,160	922	6.51	7.50
Retail trade	$704,239	2,178	15.38	8.06
Transportation & warehousing	$313,346	350	2.47	3.59
Information	$261,206	272	1.92	2.99
Finance and insurance	$671,056	858	6.06	7.68
Real estate/rental/leasing	$118,612	718	5.07	1.36
Professional/scientific/technical services	$628,648	1,357	9.58	7.20
Management of companies and enterprises	$300,091	85	0.60	3.44
Administration, support, waste management, remediation services	$304,805	670	4.73	3.49
Educational services	$316,870	128	0.90	3.63
Health care and social assistance	$1,487,778	1,461	10.32	17.04
Arts, entertainment and recreation	$38,769	260	1.84	0.44
Accommodation and food services	$255,332	1,350	9.53	2.92
Other services (except public administration)	$255,329	1,467	10.36	2.92
Unclassified establishments	No data	26	0.18	No data
Source: U.S. Census Bureau, County Business Patterns, 2006				

Manufacturers in the region operate fewer, larger establishments and have a higher relative significance as sources of payroll on a per capita basis. Representing only 4% of the region's business establishments and employing only 10.7% of the work force, manufacturers generate over 16% of the region's total payroll. By contrast, there are over 2,000 retail establishments (15% of the total) in the region which employ nearly 12% of the work force yet this sector provides only 8% of the overall payroll. The health care and social service sector show a similar disproportionate contribution to payroll (17%) in terms of the number of establishments (10.3%) and percentage of work force employed (12.5%).

The value of a manufacturing or health care business in the region is considerable in terms of its creation of well-paying jobs and as such attraction and retention efforts involving these industries tend to enjoy the support of the community.

8.2.2 Largest Private Employers in Onondaga/Oswego Counties

With the foregoing background in mind, it is now time to consider the specific employers that constitute the major economic entities in the region. Tables 8-3 and 8-4 provide employment data, sector identification, and location for the largest employers in Onondaga and Oswego Counties, respectively.

Table 8-3 lists the largest employers in Onondaga County and shows the fairly diverse employment base of the county and shows the trend noted in Table 8-2 in which the larger establishments tended to be in the manufacturing and health care sectors. There is an understandable concentration of employers in the City of Syracuse and another cluster of larger firms in East Syracuse and DeWitt.

Table 8-3. Onondaga County's Largest Employers: 2007 Full-Time CNY Employees

Name	Full Time CNY Employees	Industry	Location
SUNY Upstate Medical University	6,500	Health Care.	Syracuse
Syracuse University	5,047	Educational Services	Syracuse
Wegmans Food Markets, Inc.	3,655	Retail Grocer	Various
St. Joseph's Health Center	3,141	Health Care	Syracuse

Table 8-3. Onondaga County's Largest Employers: 2007 Full-Time CNY Employees (Continued)

Name	Full Time CNY Employees	Industry	Location
Magna Powertrain - NPG	3,000	Manufacturing - Auto	East Syracuse
Crouse Hospital	2,560	Health Care	Syracuse
Penn Traffic/P&C	2,500	Retail/Distribution	Syracuse
Verizon	2,447	Telecom	Syracuse
Loretto	2,411	Health Care/Social Services	Syracuse
Lockheed-Martin - MS2	2,350	Tech. Service	Liverpool
National Grid	1,764	Utility	Syracuse
Carrier	1,300	Tech. Service	DeWitt
UPS	1,226	Delivery Service	East Syracuse
Syracuse VA Medical	1,200	Health Care	Syracuse
Welch Allyn, Inc.	1,200	Manufacturing - Medical	Skaneateles

A similar trend is evident in Table 8-4 in that the larger employers in Oswego County tend to be in the manufacturing and health care/social service sector. A more pronounced concentration of these employers is seen in Fulton.

Table 8-4. Oswego County's Largest Employers: 2007 Full-Time CNY Employees

Name	Full Time CNY Employees	Industry	Location
SUNY Oswego	1,192	Education	Oswego
Constellation Energy	900	Energy	Lycoming
Novelis Corp.	714	Mfg. - Metal	Oswego
Entergy Nuclear Northeast	700	Energy	Lycoming
Huhtamaki	630	Mfg.- Food packaging	Fulton
Oswego Health, Inc.	531	Health Care	Oswego

Table 8-4. Oswego County's Largest Employers: 2007 Full-Time CNY Employees (Continued)

Name	Full Time CNY Employees	Industry	Location
Wal-Mart	460	Retail	Oswego/ Central Square
Oswego County Opportunities	415	Human Services	Fulton
Oswego Industries	412	Human Services	Fulton
Omega Wire	292	Mfg.- Metal	Williamstown
Birds Eye Food Co.	290	Food Processor	Fulton
A. L. Lee Memorial Hospital	269	Health Care	Fulton
Felix Schoeller Technical Papers	235	Mfg.- Specialty Paper	Pulaski
The Fulton Companies	232	Mfg.- Heating Equipment	Pulaski
St. Luke Health Services	212	Health Care	Oswego

Even though the manufacturing sector trend in the region is negative, manufacturing industries still account for a significant amount of the region's employees and payroll. As pointed out previously, manufacturing businesses quite frequently provide higher paying jobs than created in other sectors and so are highly prized targets of attraction and retention efforts by economic development agents. Tables 8-5 and 8-6 show Onondaga/Oswego County's largest manufacturers, their full-time employment numbers, sector and geographic location.

Table 8-5. Onondaga County's Largest Manufacturers: 2007 CNY Employees

Name	Employees	Industry	Location
Magna Powertrain	3,000	Automotive Products	Syracuse
Lockheed Martin MS2	2,350	Sensor Equipment	Liverpool
Welch-Allyn, Inc.	1,200	Med. Equipment	Skaneateles
L & J.G. Stickley	1,015	Furniture	Manlius
Anheuser-Busch, Inc.	940	Beverage	Baldwinsville
Bristol-Myers Squibb Co.	800	Pharmaceuticals	East Syracuse
Cooper Crouse-Hinds	675	Electrical Products	Syracuse
Crucible Materials Corp.	654	Specialty Steel	Syracuse
Sensis Corp.	580	Sensor Equipment	East Syracuse
Tessy Plastics	580	Plastic Products	Elbridge

Table 8-6. Oswego County's Largest Manufacturers: 2007 Full-Time CNY Employment

Name	Employees	Industry	Location
Novelis	714	Metal Fabrication	Oswego
Huhtamaki	630	Packaging	Fulton
Omega Wire	292	Electrical Wire	Williamstown
Birds Eye Foods Co	290	Food Processing	Fulton
Felix Schoeller Papers	235	Specialty Papers	Pulaski
The Fulton Companies	232	Heat Transfer Equipment	Pulaski
The Northern Group	187	Concrete	Fulton
Interface Solutions	150	Gaskets	Fulton
Black Clawson	140	Machinery	Fulton
Oswego Wire	98	Wire and Cable	Oswego

Among the region's largest manufacturers, there is significant diversity in the sectors represented. There are businesses still engaged in some of the area's traditional manufacturing strongholds such as automotive products and metal fabrication as well as more recent additions in areas such as electronics. This diversity is reflected in the skill-sets of the local work force and in the vocational training resources that exist in the region.

It is also important to note that no single employer or industry dominates. This type of economic stability is amplified by the relatively large number of smaller firms referred to earlier. Rather than relying on several larger employers, the CNY economy is made up of hundreds of smaller entities. This has been a source of strength in transitional times - while there have been "shocks" of large employers downsizing or leaving the area over the past several decades, smaller firms have stepped up to absorb some of the displaced workers, many of them spin-offs from the decline of the larger company. Economic echoes from the 1950's through the 1970's still reverberate in the region's economy.

While the numerous smaller economic actors that predominate the greater CNY economy do not offer the sort of concentrated and centralized utility customer that might be conducive to a District Cooling type of arrangement, economic activity in Onondaga and Oswego County is located in Syracuse, East Syracuse and Liverpool in Onondaga County and Fulton and the City of Oswego in Oswego County. If it is determined that these entities' demand for cooling is substantial, there may be sufficient "density" to make the provision of cooling from the Naturally Chilled Water viable and technically feasible.

It is also worth considering the many small and mid-sized manufacturing, commercial and services firms that are concentrated in industrial and office parks around the region. While individually they may demand little cooling, groupings of smaller businesses can be significant customers. The section below identifies these existing and developing concentrations.

8.2.3 Business and Office Parks

Table 8-7 lists the largest business and office parks in the area, as well as the area's industrial parks. There is a concentration in the northern suburbs (North Syracuse, Liverpool) of Syracuse.

Table 8-7. Largest Syracuse Area Business and Industrial Parks

Name/Location	Square Footage	Number of Buildings
Riverview Business Park (former Miller Plant), Fulton	1,100,000	Multiple tenant, acreage for build, Empire Zone, steam co-generation, on-site wastewater treatment
Widewaters Office Park DeWitt	650,000	10
Pioneer Business Park East Syracuse	350,000	8
Salina Meadows Office Park North Syracuse	308,360	5
Clay Greenfield Site, Clay	245,000	Empire Zone, Build Now NY
Sanders Creek Corporate Center East Syracuse	220,000	5
Hancock Airpark, Cicero	200,000	Empire Zone
Oswego County Industrial Park, Phoenix	152,000	
Thruway Office Park, Liverpool	106,600	1
Greenfield Corporate Office Center Liverpool	106,000	2

Table 8-7. Largest Syracuse Area Business and Industrial Parks (Continued)

Name/Location	Square Footage	Number of Buildings
Nationwide Office Building North Syracuse	101,000	1
Rodax Commercial Park Syracuse	100,800	8
Interstate Place I & II North Syracuse	61,261	2
Hancock Airport North Syracuse	60,000	17 (Recent expansion)
Independence Industrial Park, Scriba	70,000	Empire Zone, proximate to co-generation plant
Morgan Road Industrial Park, Liverpool	60,000	
Lake Ontario Industrial Park, Oswego	57,000	Empire Zone, Build Now NY
Syracuse University Research Park, Syracuse	50,000	
Electronics Park, Salina	40,000	Seven buildings
Build Now NY = Pre-permitting complete - the site is shovel ready.		

The availability of business and industrial parks is often a key economic development resource. The availability of ready-to-build sites, e.g., those sites with permit pre-approval, environmental clearance and the presence of at least basic infrastructure, including utilities, is a significant advantage for an area. Many industrial parks, while not hosting significant economic activity yet, may soon be sites for concentrations of economic activity. Developers and owners of these sites may favor access to chilled water cooling resources.

8.3 Section Summary

The important CNY employers are identified and located. The employers reflect a balanced economy as described in Section 4 of this report. It is noted that four of the 15 largest employers are located in the University area (Table 8-3).

9.0 Energy Considerations for Use of Naturally Chilled Water

9.1 Section Introduction

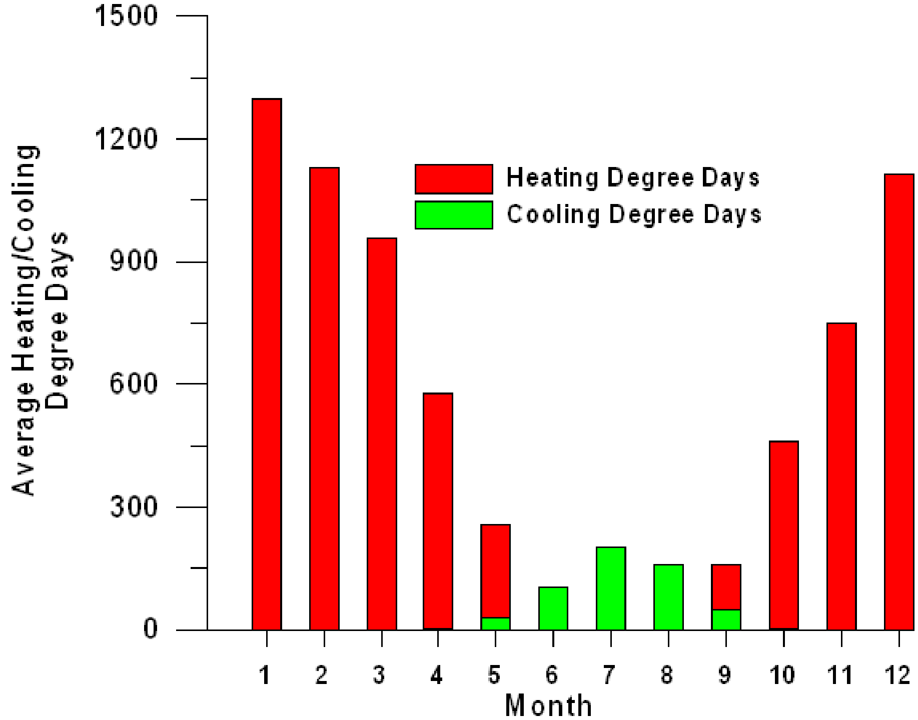
Heating and cooling requirements for Central New York businesses are reviewed, and the requirements are related to electricity usage. An estimate of cooling demand for CNY establishments is presented, with demands based on square footage and historical data from the Cornell University Lake Source Cooling project.

9.2 Basic Climate Information - Comfort Cooling Requirement

A fairly quick method of assessing regional demand for comfort heating or cooling is the review of the average heating and /or cooling degree days. Degree-days are relative measurements of outdoor air temperature used as an index for heating and cooling energy requirements. Heating degree-days (HDD) are the number of degrees that the daily average temperature falls below 65°F (18.3°C). Cooling degree-days (CDD) are the number of degrees that the daily average temperature rises above 65°F (18.3°C). The daily average temperature is the mean of the maximum and minimum temperatures in a 24-hour period. For example, a weather station recording an average daily temperature of 40°F (4.4°C) would report 25 heating degree-days for that day (and 0 cooling degree-days). If a weather station recorded an average daily temperature of 78°F (25.6°C), cooling degree-days for that station would be 13 (and 0 heating degree days).

Figure 9-1 provides average monthly information for both HDD and CDD for Syracuse over a 30-year period.

Figure 9-1. Syracuse, NY - Average Heating and Cooling Degree Days by Month



The Syracuse area is clearly a cooler climate than, say, South Carolina or Arizona. Yet the need for comfort cooling exists from April to October. Cooling may be required more frequently for office buildings and industrial settings where heat is generated from office and production equipment and from workers themselves, especially where natural ventilation is not available.

9.3 Estimates of Average and Peak Cooling Energy Usage

9.3.1 Cooling Types

Energy needs for cooling can be divided into two large groups - process cooling and comfort cooling. Many industries use process cooling in the manufacturing of their products. Such process cooling is usually supplied by a mechanical chiller with either a water cooling tower or air cooled coils. Comfort cooling for office space is supplied either by distributed cooling systems or centralized cooling systems. An example of a distributed cooling system is an older university building with window mounted air conditioners in each room. Centralized cooling systems are only possible in buildings with a centralized air distribution system. In a centralized system air is distributed to the various rooms within a building by a central unit equipped with a cooling coil. A mechanical chiller is generally used to cool the coil, and then heat is dissipated from the chiller to the atmosphere using either a water cooling tower or air cooled coils.

For the purposes of this project the candidates with the most potential to benefit from a NCW chilled water loop are those with existing process cooling loads and office/institutional buildings with existing centralized cooling systems. For these cooling loads the chilled water loop could replace the cooling currently provided by mechanical chillers, allowing for energy and cost savings.

9.3.2 Cooling Energy Units

Cooling system energy usage involves heat transfer from inside the building (heat removed) to outside the building (heat rejected). The total heat rejected is a total of the heat removed and the amount of energy used by the refrigeration system and its components (energy into the compressor and pump motors). The common units of thermal transfer are the British Thermal Unit (BTU) and refrigeration ton-hours (ton-hrs). A BTU is the amount of heat required to increase the temperature of one pound of water 1 ºF. A ton-hr of refrigeration is defined as 12,000 BTUs. The instantaneous unit of cooling (a measurement of energy per unit time) is either BTU/hr or tons. A ton is equivalent to 12,000 BTU/hr, originally derived from the energy needed to melt 1 ton of ice over 24 hours. As an example, a 100,000 ft^2 (9,300 m^2) single-story office building in our climate might have a peak summer hourly cooling load of about 2,000,000 BTU/hr, equivalent to 167 tons.

9.3.3 Relation to Electrical Power

The cooling required for most buildings is supplied by mechanical chillers. These chillers use electricity to cool fluids (typically water), which in turn cool the air in the building. Mechanical chillers use approximately 0.7 kilowatts (kW) of electrical power for each ton of cooling they provide. Auxiliary equipment including cooling towers and condenser pumps adds to the chiller power usage and increases typical total power usage to 0.8 to 1.0 kW/ton. On an annual average total power usage is about 0.9 kW/ton. During the peak hour in our previous example, the 167 tons of cooling provided by the mechanical chiller would consume 150 (167 tons x 0.9 kW/ton) kilowatt-hours (kWh) of electricity. At an average price of $0.12 per kWh this peak cooling hour would cost $18.00.

9.3.4 Peak and Average Cooling Energy Usage

Comfort cooling systems are designed to deliver a maximum amount of cooling equal to the peak hourly cooling load expected. This allows the systems to provide the cooling required during peak periods, and provide lesser amounts of cooling during other periods. For office buildings in the CNY region this peak hourly cooling load can be correlated to the area of the building. Cooling system peak sizing for various types of buildings in CNY is shown in Table 9-1.

Table 9-1. Peak Hourly Cooling Loads, Tons per 1,000 Square Feet of Building Space

Building Type	Peak Load (Tons)
Educational buildings	1.67
Hospitals	2.50
Office buildings	1.67
Shopping malls, retail	1.67
Source: Data compiled by Cornell University for educational and office buildings at Cornell University. Extrapolation for hospitals and shopping malls is based on ASHRAE HVAC Fundamentals Handbook[a]	

a. Peak to Average Cooling Load Ratio. See 1989 Fundamentals Edition, American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook, example 16 on page 26.52

The relationship between average cooling energy usage and peak usage varies based on many factors. The number of people using a building, the lighting type and duration, the amount of electrical office equipment, building shape, type of windows, and many other factors are used to develop an hour by hour heat load calculation which corresponds to how much cooling is required in the building.[1]

The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), maintains a set of technical references used to design heating and cooling systems for buildings. The 1989 ASHRAE Fundamentals Handbook outlines a method to estimate the hourly cooling load for a build-

1. Annual cooling load. From the United States Department of Energy website, http://www1.eere.energy.gov/femp/procurement/eep_ac_chillers_calc.html, as discussed with a Carrier Corporation HVAC engineer familiar with design conditions in the CNY area.

ing, which in turn yields the peak hourly cooling load. The ASHRAE method shows that a single story office building is likely to have a peak hourly cooling load in mid-afternoon which is approximately 3.6 times higher than the minimum hourly cooling load (which is normally recorded during the early morning). This generalization assumes that the office building is occupied by people during the day, but not at night, and that lights are turned off during the unoccupied periods. The comfort cooling load varies significantly by hour of day, with occupied daylight hours having an hourly cooling load approximately two to three times the typical hourly nighttime load.

In CNY, the cooling systems in most office buildings, universities, and hospitals run for approximately six to seven months per year (April or May until November). Peak cooling loads are typically only developed during the warmest weather in portions of July and August.

Industry rules of thumb for the CNY latitude estimate that the total annual energy use for a cooling system at our latitude can be estimated as the equivalent of 1000 hours of cooling system operation at peak load. For comparison, cooling systems near Atlanta, Georgia, would be expected to run for an equivalent annual energy load of 1,600 peak hours; and systems in Dallas, Texas, would run for an annual average of approximately 2,000 peak hours. Table 9-2 (shown at the end of this section) lists the peak hourly and annual average energy use for the industries and institutions shown.

9.3.5 Estimates of Energy Costs Associated with Average and Peak Energy Usage for Cooling

Almost all mechanical cooling systems run on purchased electricity. Industries, educational institutions, and office buildings in Central New York contract for electrical power using a variety of different rate structures. The different rate structures consider different aspects of electrical power usage such as: (1) time of day; (2) peak electrical demand per 15 minutes or 60 minutes; and (3) ratio of average usage to peak usage.

For most customers, the complicated rate structure can be reduced to an approximate cost per kilowatt-hour of electrical power used. Information from the New York State Energy Research and Development Agency[1] (NYSERDA) was used to develop the cost estimates shown in Table 9-2. A flat electrical rate of $0.12/kWh was used for the cost estimates. As the table

1. Electrical prices, from the New York State Energy Research and Development Agency (NYSERDA) website at http://www.nyserda.org/Energy_Information/electricity.asp

shows, the entities listed purchase electricity worth over $5 million per year to provide cooling to their buildings and processes.

9.3.6 Cooling Energy Use by Economic Sector in Onondaga and Oswego Counties

The total amount of energy used for cooling includes both the actual energy used by mechanical chillers and the energy consumed at regional power plants to produce and transmit electricity to the chillers. The amount of electrical energy used to drive mechanical chillers is listed in Table 9-2 for each of the entities identified as potential chilled water customers.

Table 9-2 includes columns showing both direct cooling energy cost and indirect cooling energy. The term “Indirect Cooling Energy” used in this report represents the amount of energy used to produce and transmit the electrical power consumed as direct cooling energy. Fossil fuel burning electrical generating plants produce approximately two thirds of the electricity consumed in the United States each year[1]. Electric generating plants which burn fossil fuels to produce electricity have overall operating efficiencies of approximately 35 percent[2], meaning that only about a third of the total energy produced is converted to electricity. The remaining energy, mostly in the form of heat, is released to the environment with no beneficial use. Besides the heat lost during electrical generation, there is an additional loss of energy associated with transmitting the electricity from the generating plant to the buildings where it is used. Transmission losses range from 5 to 9.5 percent[3], and losses of 7% are used in this report.

9.3.7 Analysis of Potential Benefits to Each Sector

The amount of economic benefit available to each industrial entity is clearly shown on Table 9-2 and relates to the cost of purchased electricity which could be eliminated if chilled water were available at no cost. The importance of the potential economic benefit to any sector appears to be minor. The cost of electrical power for cooling represents a small part of the total electrical bill for most sectors. Furthermore, electrical costs represent a

1. Fossil Fuel Electrical Generation. From the United States Department of Energy website, http://www.energy.gov/energysources/fossilfuels.htm

2. Generating efficiency. From Topic Paper #4, Electric Generation Efficiency, National Petroleum Council, July 18, 2007.

3. Transmission losses. From the United States Department of Energy website, http://www.energetics.com/gridworks/grid.html.

minor portion of the overall operating budget of most entities when the costs of payroll, benefits, raw materials, capital costs and other services are considered.

The only potential sector where the elimination of electrical cooling costs may be a significant benefit is the metals industry, where large amounts of cooling are needed. In the Central New York Region, the Novelis aluminum facility near Oswego is the best example of the type of industry which could benefit from a chilled water plant. Novelis is located on the shore of Lake Ontario, and already uses the cold water available in the lake to supply its cooling needs.

9.4 Identification of Specific Potential Customers in Onondaga and Oswego Counties

A list of specific potential customers in Central New York was developed as a part of this task. Table 9-2 shows approximately 100 potential customers with information on cooling requirements for each.

9.4.1 Summary of Chilled Water Needs for Similar Industries

The major industrial sectors identified in Section 5 included education, hospitals, and office buildings, and shopping malls. The chilled water needs for each of these sectors is accurately represented by the industries and institutions shown in Table 9-2. Table 9-2 also clearly shows that typically sized buildings in each sector will have cooling systems ranging from 50 to 500 tons which could benefit from the use of chilled water in place of mechanical chilling.

9.5 Section Summary

A review of cooling requirements in CNY showed that cooling systems typically run from April or May until November. Different building types generate different cooling requirements (Table 9-1). Almost all current cooling systems are powered by electricity at an average cost of $0.12 per kiloWatt-hour. The total energy cost for cooling in CNY is on the order of $6 million per year (Table 9-2). Geographically, the highest density of potential Naturally Chilled Water customers is in the Syracuse downtown/University area (Table 9-2).

Table 9-2. Analysis of Comfort and Process Cooling Requirements for Potential Chilled Water Customers

Industry or Institution (Type)	Cooled Building Area (Square Feet)[a]	Comfort Cooling		Process Cooling		Total Annual Cooling Load (Ton Hours)	Annual Cooling Energy Load (kWhs)[d]	Annual Cooling Cost[e]
		Peak Hourly Cooling Load (Tons)[b]	Annual Cooling Load (Ton Hours)[c]	Peak Hourly Cooling Load (Tons)	Annual Cooling Load (Ton Hours)			
Oswego Area Buildings								
SUNY Oswego (Educational)	1,000,000	1,670	2,194,380	0	0	2,194,380	1,974,942	$236,993
Oswego Hospital (Hospital)	40,000	100	175,200	0	0	175,200	157,680	$18,922
Oswego City Office Complex (Office)	45,000	75	75,150	0	0	75,150	67,637	$8,116
					Oswego Totals =	**2,444,730**	**2,200,259**	**$264,031**
Fulton Area Buildings								
Fulton Hospital (Hospital)	32,000	80	140,160	0	0	140,160	126,144	$15,137
New York Chocolate (Industry)	20,000	33	33,400	100	20,000	53,400	48,060	$5,767
Northeast Biofuels and Business Park (Industry)	10,000	17	16,700	0	0	16,700	15,030	$1,804
Davis Standard (Industry)	1,000	2	1,670	10	2,000	3,670	3,303	$396
Birdseye Foods (Industry)	500	1	1,097	100	20,000	21,097	18,987	$2,278
Huhtamaki (Industry)	1,000	2	1,670	10	2,000	3,670	3,303	$396

Table 9-2. Analysis of Comfort and Process Cooling Requirements for Potential Chilled Water Customers

Industry or Institution (Type)	Cooled Building Area (Square Feet)[a]	Comfort Cooling		Process Cooling		Total Annual Cooling Load (Ton Hours)	Annual Cooling Energy Load (kWhs)[d]	Annual Cooling Cost[e]
		Peak Hourly Cooling Load (Tons)[b]	Annual Cooling Load (Ton Hours)[c]	Peak Hourly Cooling Load (Tons)	Annual Cooling Load (Ton Hours)			
Interface Solutions (Industry)	2,000	3	3,340	10	2,000	5,340	4,806	$577
				Fulton	**Totals =**	**244,037**	**219,633**	**$26,355**
Syracuse Downtown Area Buildings								
National Grid Building (Office)	511,200	854	853,704	0	0	853,704	768,333	$92,200
Post Standard Buildings (Office)	179,000	299	298,930	0	0	298,930	269,037	$32,284
SUNY ESF (Educational)	1,000,000	1,670	2,194,380	0	0	2,194,380	1,974,942	$236,993
Hotel Syracuse (Hotel)	720,000	1,202	1,202,400	0	0	1,202,400	1,082,160	$129,859
Harrison Building (Office)	252,000	421	420,840	0	0	420,840	378,756	$45,451
St. Josephs Hospital (Hospital)	780,000	1,950	3,416,400	0	0	3,416,400	3,074,760	$368,971
Syracuse University Main Campus (Educational)	2,000,000	3,340	4,388,760	0	0	4,388,760	3,949,884	$473,986
Carrier Dome	360,000	601	789,977	0	0	789,977	710,979	$85,315
Museum of Science and Technology	40,000	67	87,775	0	0	87,775	78,998	$9,480
AXA Towers (Office)	1,400,000	2,388	2,338,000	0	0	2,338,000	2,104,200	$252,504

Table 9-2. Analysis of Comfort and Process Cooling Requirements for Potential Chilled Water Customers

Industry or Institution (Type)	Cooled Building Area (Square Feet)[a]	Comfort Cooling		Process Cooling		Total Annual Cooling Load (Ton Hours)	Annual Cooling Energy Load (kWhs)[d]	Annual Cooling Cost[e]
		Peak Hourly Cooling Load (Tons)[b]	Annual Cooling Load (Ton Hours)[c]	Peak Hourly Cooling Load (Tons)	Annual Cooling Load (Ton Hours)			
Syracuse War Memorial (Entertainment)	180,000	301	394,988	0	0	394,988	355,489	$42,659
Center of Excellence (Office)	100,000	167	167,000	0	0	167,000	150,300	$18,306
State Tower Building (Office)	1,200,000	2,004	2,004,000	0	0	2,004,000	1,803,600	$216,432
Upstate Medical Center (Hospital)	720,000	1,800	3,153,600	0	0	3,153,600	2,838,240	$340,589
Crouse Irving Hospital (Hospital)	1,200,000	3,000	5,256,000	0	0	5,256,000	4,730,400	$567,648
VA Hospital (Hospital)	400,000	1,000	1,752,000	0	0	1,752,000	1,576,800	$189,216
University Hospital (Hospital)	450,000	1,125	1,971,000	0	0	1,971,000	1,773,900	$212,868
Clinton Exchange Building (Office)	180,000	301	300,600	0	0	300,600	270,540	$32,465
Quinlivan Building (Office)	43,200	72	72,144	0	0	72,144	64,930	$7,792
Onondaga County Savings Bank (Office)	365,000	610	609,550	0	0	609,550	548,595	$65,831
Atrium Building (Office)	219,000	366	365,730	0	0	365,730	329,157	$39,499

Table 9-2. Analysis of Comfort and Process Cooling Requirements for Potential Chilled Water Customers

Industry or Institution (Type)	Cooled Building Area (Square Feet)[a]	Comfort Cooling		Process Cooling		Total Annual Cooling Load (Ton Hours)	Annual Cooling Energy Load (kWhs)[d]	Annual Cooling Cost[e]
		Peak Hourly Cooling Load (Tons)[b]	Annual Cooling Load (Ton Hours)[c]	Peak Hourly Cooling Load (Tons)	Annual Cooling Load (Ton Hours)			
Chase Bank Building (Office)	202,000	337	337,340	0	0	337,340	303,606	$36,433
Citizens Bank Building (Office)	360,000	601	601,200	0	0	601,200	541,080	$64,930
Federal Office Building (Office)	338,000	564	564,460	0	0	564,460	508,014	$60,962
Warehouse Galleries (Office)	72,000	120	120,240	0	0	120,240	108,216	$12,968
State Office Building (Office)	360,000	601	601,200	0	0	601,200	541,080	$64,930
300 East Washington (Office)	923,000	1,541	1,541,410	0	0	1,541,410	1,387,269	$166,472
Hills Building (Office)	100,000	167	167,000	0	0	167,000	150,300	$18,036
Key Bank Building (Office)	132,000	220	220,440	0	0	220,440	198,396	$23,808
Hiscock and Barclay Building (Office)	330,000	551	551,100	0	0	551,100	495,990	$59,519
Civic Center (Office)	1,350,000	2,255	2,254,500	0	0	2,254,500	2,029,050	$243,486
Onondaga County Courthouse (Office)	450,000	752	751,500	0	0	751,500	676,350	$81,162
Court House (Office)	717,000	1,197	1,197,390	0	0	1,197,390	1,077,651	$129,318
Court Offices (Office)	225,000	376	375,750	0	0	375,750	338,175	$40,581

Table 9-2. Analysis of Comfort and Process Cooling Requirements for Potential Chilled Water Customers

Industry or Institution (Type)	Cooled Building Area (Square Feet)[a]	Comfort Cooling		Process Cooling		Total Annual Cooling Load (Ton Hours)	Annual Cooling Energy Load (kWhs)[d]	Annual Cooling Cost[e]
		Peak Hourly Cooling Load (Tons)[b]	Annual Cooling Load (Ton Hours)[c]	Peak Hourly Cooling Load (Tons)	Annual Cooling Load (Ton Hours)			
Police Building (Office)	210,000	351	350,700	0	0	350,700	315,630	$37,876
Landmark Theater (Entertainment)	37,500	63	82,289	0	0	82,289	74,060	$8,887
Syracuse Stage (Entertainment)	30,000	50	65,831	0	0	65,831	59,248	$7,110
EM O'Donnell Building (Office)	50,000	84	83,500	0	0	83,500	75,150	$9,018
100 Clinton Square (Office)	120,000	200	200,400	0	0	200,400	180,360	$21,643
Dannible and McKee (Office)	180,000	301	300,600	0	0	300,600	270,560	$32,465
Verizon Building (Office)	600,000	1,002	1,316,628	0	0	1,316,628	1,184,965	$142,196
OnCenter Convention Center (Office)	180,000	301	300,600	0	0	300,600	270,540	$32,465
Carousel Mall	240,000	401	526,651	0	0	526,651	473,986	$56,878
Rosamond Gifford Zoo (Office)	20,000	33	33,400	0	0	33,400	30,060	$3,607
Harrison Center Medical Building (Office)	90,000	150	150,300	0	0	150,300	135,270	$16,232
City Hall (Office)	96,000	160	160,320	0	0	160,320	144,289	$17,315
Anoplate (Industry)	1,500	3	2,505	100	2,000	4,505	4,055	$487

Table 9-2. Analysis of Comfort and Process Cooling Requirements for Potential Chilled Water Customers

Industry or Institution (Type)	Cooled Building Area (Square Feet)[a]	Comfort Cooling		Process Cooling		Total Annual Cooling Load (Ton Hours)	Annual Cooling Energy Load (kWhs)[d]	Annual Cooling Cost[e]
		Peak Hourly Cooling Load (Tons)[b]	Annual Cooling Load (Ton Hours)[c]	Peak Hourly Cooling Load (Tons)	Annual Cooling Load (Ton Hours)			
Cooper/Crouse Hinds (Industry)	45,000	75	75,150	0	0	75,150	67,635	$8,116
Syracuse Savings Bank (Office)	57,600	96	96,192	0	0	96,192	86,573	$10,389
Downtown Syracuse Totals =						**45,068,374**	**40,561,538**	**$4,867,385**
Outlying Buildings								
LeMoyne College (Educational)	1,000,000	1,670	2,194,380	0	0	2,194,380	1,974,942	$236,993
Onondaga Community College (Educational)	1,000,000	1,670	2,194,380	0	0	2,194,380	1,974,942	$236,993
Anheuser Busch (Industry)	45,000	75	75,150	150	30,000	105,150	94,635	$11,356
Carrier (Industry)	20,000	33	33,400	0	0	33,400	30,060	$3,607
Bristol Myers (Industry)	450,000	752	751,500	1,000	600,000	1,351,500	1,216,359	$145,963
Crucible Steel (Industry)	7,500	13	12,525	100	20,000	32,525	29,273	$3,513
Solvay Paperboard (Industry)	12,000	20	20,040	100	20,000	40,040	36,036	$4,324
Community Hospital (Hospital)	450,000	1,125	1,971,000	0	0	1,971,000	1,773,900	$212,869
River Valley Foods (Industry)	5,000	8	8,350	100	20,000	28,350	25,515	$2,892

Table 9-2. Analysis of Comfort and Process Cooling Requirements for Potential Chilled Water Customers

Industry or Institution (Type)	Cooled Building Area (Square Feet)[a]	Comfort Cooling		Process Cooling		Total Annual Cooling Load (Ton Hours)	Annual Cooling Energy Load (kWhs)[d]	Annual Cooling Cost[e]
		Peak Hourly Cooling Load (Tons)[b]	Annual Cooling Load (Ton Hours)[c]	Peak Hourly Cooling Load (Tons)	Annual Cooling Load (Ton Hours)			
Ultradairy (Industry)	8,000	13	13,360	100	20,000	33,360	28,356	$3,062
Agway Office Building (Office)	120,000	200	200,400	0	0	200,400	186.360	$21,643
Lockheed Martin (Office)	100,000	167	167,000	0	0	167,000	150,300	$18,036
MAGNA (Industry)	200,000	334	334,000	0	0	334,000	300,600	$36,072
Great Northern Mall (Retail)	225,000	376	493,736	0	0	493,736	444,362	$53,323
Woodard Industrial Park (Office)	4,000	7	6,680	10	2,000	8,680	7,812	$937
Penn Can Mall (Retail)	100,000	167	219,438	0	0	219,438	197,494	$23,700
Hancock Airport (Office)	100,000	167	167,000	0	0	167,000	150,300	$18,036
Syracuse University Skytop Area (Office)	800,000	1,336	1,336,000	0	0	1,336,000	1,202,400	$194,288
Shoppingtown Mall (Retail)	180,000	301	394,988	0	0	394,988	355,489	$42,659
State Fair Complex (Office)	7,500	13	12,525	0	0	12,525	11,273	$1,353
Alliance Bank Stadium (Office)	2,500	4	4,175	0	0	4,175	3,758	$451
BG Sulzle (Industry)	50,000	84	83,500	0	0	83,500	75,150	$9,018
GA Braun (Industry)	25,000	42	41,750	0	0	41,750	37,575	$4,509

Table 9-2. Analysis of Comfort and Process Cooling Requirements for Potential Chilled Water Customers

Industry or Institution (Type)	Cooled Building Area (Square Feet)[a]	Comfort Cooling		Process Cooling		Total Annual Cooling Load (Ton Hours)	Annual Cooling Energy Load (kWhs)[d]	Annual Cooling Cost[e]
		Peak Hourly Cooling Load (Tons)[b]	Annual Cooling Load (Ton Hours)[c]	Peak Hourly Cooling Load (Tons)	Annual Cooling Load (Ton Hours)			
Wyndham Hotel at Carrier Circle (Hotel)	25,000	42	41,750	0	0	41,750	37,575	$4,509
Sensis (Office)	22,500	38	37,575	0	0	37,575	33,813	$4,058
Widewaters Plaza (Office)	250,000	418	417,500	0	0	417,500	375,750	$45,090
Outlying Buildings Total =						**11,944,102**	**10,749,702**	**$1,289,965**
Oswego - Onondaga County Totals =	**26,176,500**	**47,148**	**58,941,243**	**1,890**	**760,000**	**59,701,243**	**53,731,132**	**$6,447,736**

a. Square footages are estimates.
b. Peak cooling loads based on type and use of building, per Cornell University data (see Table 9-1).
c. Annual cooling loads derived from historical data from Cornell University.
d. Equivalent kWhs based on equipment efficiency of 0.9 kW/ton, from US Department of Energy website http://www1.eere.energy.gov/femp/procurement/eep_wc_chillers.html
e. Energy cost $0.12 per kWh based on data from NYSERDA at http://www.nyserda.org/Energy_Information/nyep9.pdf/

10.0 Characterize Needs of Potential Customers

10.1 Section Introduction

The success of a district cooling application will be influenced by the dependability of the system's infrastructure and the quality of the chilled water delivered. The means used to deliver and distribute chilled water will greatly affect the cost of the system, and the method for returning warmed water to the ecosystem will have environmental effects which must be considered.

10.2 Chilled Water Needs for Existing and Future Potential Customers

The total volume of chilled water to be moved to the Syracuse area is a basic starting point in assessing the feasibility of the system. The list of potential customers developed in Section 9 has been refined to a smaller subset of institutional, commercial and industrial entities which have a higher likelihood of benefiting from a chilled water system. Potential customers from the original list were removed if the cooling system employed was not centralized, or if the physical location of the building was far away from the proposed route of the transmission pipeline. The resulting list of high potential customers is shown in Table 10-1. The table also shows the chilled water flow rate required for the peak cooling hour, based on several assumptions which are discussed in this section.

10.2.1 Water Volume Required

If every high potential customer was supplied with chilled water during the peak cooing hour, the total flow required would be approximately 73,800 gallons per minute, which equates to a flow rate of 106 million gallons per day. The list of high usage potential customers shown in Table 10-1 can be further refined once an exact route for the transmission line through the downtown area is determined.

Table 10-1. Potential High Usage Customers for Chilled Water

Industry or Institution (Type)	Cooled Building Area[a] (ft^2)	Total Annual Cooling[b] (Ton hours)	Annual Cooling Energy Load (kWh)	Annual Cooling Cost[c] ($)	Chilled Water Flow During Peak Hour (GPM)	Peak Hour Cooling Load (Tons)	Required Pipe Diameter (inch)	Distance from Pipeline (ft)
Oswego Area Buildings								
SUNY Oswego (Educational)	1,000,000	2,194,380	1,974,542	$236,993	3,337	1670	16	1,000
Downtown Area Buildings								
National Grid Building (Office)	511,200	853,704	768,333	$92,900	1,706	854	10	2,400
Post Standard Building (Office)	179,000	298,930	269,037	$32,284	597	299	6	1,100
SUNY-ESF (Educational)	1,000,000	2,194,380	1,974,942	$236,993	3,337	1670	16	300
Hotel Syracuse (Hotel)	720,000	1,202,400	1,082,160	$129,859	2,403	1202	12	900
Harrison Building (Office)	252,000	420,840	378,756	$45,451	841	421	8	600
St. Joseph's Hospital (Hospital)	780,000	3,416,400	3,074,760	$368,971	3,897	1950	16	200
Syracuse University Main Campus (Educational)	2,000,000	4,388,760	3,949,884	$473,986	6,675	3340	20	500
Carrier Dome	360,000	789,977	710,979	$85,315	1,201	601	10	300

Table 10-1. Potential High Usage Customers for Chilled Water (Continued)

Industry or Institution (Type)	Cooled Building Area[a] (ft^2)	Total Annual Cooling[b] (Ton hours)	Annual Cooling Energy Load (kWh)	Annual Cooling Cost[c] ($)	Chilled Water Flow During Peak Hour (GPM)	Peak Hour Cooling Load (Tons)	Required Pipe Diameter (inch)	Distance from Pipeline (ft)
Museum of Science and Technology	40,000	87,775	78,998	$9,840	133	67	4	2,800
AXA Towers (Office)	1,400,000	2,338,000	2,104,200	$252,504	4,672	2388	18	800
Syracuse War Memorial (Entertainment)	180,000	394,988	355,489	$42,659	601	301	6	100
Center of Excellence Building (Office)	100,000	167,000	150,300	$18,306	334	167	6	2,400
State Tower Building (Office)	1,200,000	2,004,000	1,803,600	$216,432	4,005	2004	16	300
Upstate Medical Center (Hospital)	720,000	3,153,600	2,838,240	$340,589	3,597	1,800	16	1,500
VA Hospital	400,000	1,752,000	1,576,800	$189,216	1,999	1,000	12	100
Crouse Irving Hospital	1,200,000	5,256,000	4,730,400	$567,648	5,995	3,000	20	500
University Hospital	450,000	1,971,000	1,773,900	$212,868	2,248	1,125	12	500
Clinton Exchange Building (Office)	180,000	300,600	270,540	$32,465	601	301	6	2,000
Quinlivan Building (Office)	43,200	72,144	64,930	$7,792	144	72	4	400

Table 10-1. Potential High Usage Customers for Chilled Water (Continued)

Industry or Institution (Type)	Cooled Building Area[a] (ft^2)	Total Annual Cooling[b] (Ton hours)	Annual Cooling Energy Load (kWh)	Annual Cooling Cost[c] ($)	Chilled Water Flow During Peak Hour (GPM)	Peak Hour Cooling Load (Tons)	Required Pipe Diameter (inch)	Distance from Pipeline (ft)
Onondaga County Savings Bank (Office)	365,000	609,550	548,595	$65,831	1,218	610	10	300
Atrium Building (Office)	219,000	365,730	329,1571	$39,499	731	366	8	300
Chase Bank Building (Office)	202,000	337,340	303,606	$36,433	674	337	8	300
Citizens Bank Building (Office)	360,000	601,200	541,080	$64,930	1,201	601	10	300
Federal Office Building (Office)	338,000	564,460	508,014	$60,962	1,128	564	10	1,500
Warehouse Galleries Buildings (Office)	72,000	120,240	108,216	$12,968	240	120	4	2,400
State Office Building (Office)	360,000	601,200	541,080	$64,930	1,201	601	10	700
300 East Washington (Office)	923,000	1,541,410	1,387,269	$166,472	3,080	1,541	16	300
Hills Building (Office)	100,000	167,000	150,300	$18,036	334	167	6	200
Key Bank Building (Office)	132,000	220,440	198,396	$23,808	441	220	6	100

Table 10-1. Potential High Usage Customers for Chilled Water (Continued)

Industry or Institution (Type)	Cooled Building Area[a] (ft^2)	Total Annual Cooling[b] (Ton hours)	Annual Cooling Energy Load (kWh)	Annual Cooling Cost[c] ($)	Chilled Water Flow During Peak Hour (GPM)	Peak Hour Cooling Load (Tons)	Required Pipe Diameter (inch)	Distance from Pipeline (ft)
Hiscock and Barclay Building (Office)	330,000	551,100	495,900	$59,519	1,101	551	8	100
Civic Center (Office)	1,350,000	2,254,500	2,029,050	$243,486	4,505	2,255	16	300
Onondaga County Courthouse (Office)	450,000	751,500	676,350	$81,162	1,502	752	10	50
Court House (Office)	717,000	1,197,390	1,077,651	$129,318	2,393	1,197	12	50
Court Offices (Office)	225,000	375,750	338,175	$40,581	751	376	8	50
Police Building (Office)	210,000	350,700	315,630	$37,876	701	351	8	50
Landmark Theater (Entertainment)	37,500	82,289	74,060	$8,887	125	63	4	1,800
Syracuse Stage (Entertainment)	30,000	65,831	59,248	$7,110	100	50	4	2,200
EM O'Donnell Building (Office)	50,000	83,500	75,150	$9,018	167	84	4	2,400
100 Clinton Square (Office)	120,000	200,400	180,360	$21,643	400	200	6	1,700
Dannible and McKee (Office)	180,000	300,600	270,560	$32,465	601	301	6	100

Table 10-1. Potential High Usage Customers for Chilled Water (Continued)

Industry or Institution (Type)	Cooled Building Area[a] (ft^2)	Total Annual Cooling[b] (Ton hours)	Annual Cooling Energy Load (kWh)	Annual Cooling Cost[c] ($)	Chilled Water Flow During Peak Hour (GPM)	Peak Hour Cooling Load (Tons)	Required Pipe Diameter (inch)	Distance from Pipeline (ft)
Verizon Building (Office)	600,000	1,316,628	1,184,965	$142,196	2,002	1,002	12	100
Carousel Mall	240,000	526,651	447,654	53,718	801	401	8	1,000
Totals		**46,442,287**	**37,610,722**	**4,513,359**	**73,720**			

a. Square footages are estimates.

b. Annual cooling loads derived from historical data from Cornell University.

e. Energy cost $0.12 per kWh based on data from NYSERDA at http://www.nyserda.org/Energy_Information/nyep9.pdf/

10.2.2 Water Pressure Required

The system operating pressure will need to consider distribution energy requirements and interface with potable water systems. Potential customers in low rise buildings may be able to use the supplied chilled water without the use of water circulating pumps. In taller buildings, where the cooling equipment may be installed in higher elevations, water circulating pumps will already exist. The operating pressure of the chilled water system should be lower than that of the potable water system to avoid potential cross connections. A chilled water system operating pressure in the 30-40 pound per square inch (psi) range should be able to meet all requirements.

10.2.3 Thermal Requirements

Chilled water supplied to any customer will be used for comfort cooling by passing the water though a cooling coil in the airstream of the building. The chilled water will cool the airflow, and will warm up by some amount as it passes through the coil. Heat exchange coils can be designed and installed to harvest different amounts of heat depending on factors such as pumping pressure and cooling fin size. The water volume requirements estimated in Table 10-1 are based on a water temperature rise of 15ºF (8.3ºC) within the cooling coil, with an overall system heat transfer efficiency of 80%. The efficiency rating allows for losses in system efficiency due to aging, corrosion, or clogging of the coil.

10.2.4 Pipe Sizes Required

Table 10-1 lists the required minimum nominal pipe size for the each building's peak hourly flow. The pipe size required was derived from limiting the water velocity in the piping system to 7 feet per second (2.1.m/sec). Water velocities above 7 feet per second significantly increase the pumping power requirements and complexity of piping and supports..

10.2.5 Water Quality

The water quality requirements for a chilled water system must consider factors which may affect the mechanical equipment in contact with the water and the environment into which the warmed water will be discharged once its thermal energy has been extracted.

The use of portions of existing potable water infrastructure would resolve most water quality issues associated with the lake water conveyance systems since treatment to potable water standards would almost certainly exceed the minimum requirements needed to prevent mechanical problems with the pumps, piping, and heat exchangers likely to be used in a chilled water system. Disinfection to potable water standards would likely resolve any questions concerning transmission of invasive species from the intake point to the discharge point.

If a new non-potable pipeline is considered for transmission of water from Lake Ontario then a treatment system will need to be employed. The system will need to remove particulate and organics from the water to protect the piping and mechanical equipment. The treatment processes typically used for potable water, such as raw water screening and settling, should be sufficient to protect the mechanical components. Further consideration is being given to what measures should be taken to protect receiving waters from invasive species.

10.2.6 Chilled Water Needs for Future Potential Customers

The mix of business and industry in Central New York is well established and steady state. It seems likely that any future chilled water customers will be businesses and industries similar to those already in place, and that the cooling requirements for any future customers will also be similar to the existing offices, educational buildings, hospitals, and light industries in the region.

10.3 Chilled Water Distribution Options: Return or Non-Return

10.3.1 Return Option

In the Return Option, each potential user will be served by a chilled water supply line and a return line. After the thermal energy from the chilled water has been used by the cooling system the warmed water will be returned to the distribution point by the return line. This option has the following significant design considerations:

- The need for a pumping or distribution station near the downtown area or Onondaga Lake.
- Installation of a two-pipe system - supply and return.

10.3.2 Non-Return Option

In this option, chilled water would be provided by a new chilled water supply line. Warmed water would be discharged to the stormwater collection system nearest the building. This option has the following significant design considerations:

- Multiple discharge points for the warmed water.
- Potential use of existing potable water supply piping.
- Consideration of the environmental effects of multiple water discharges.
- Evaluation of the existing stormwater infrastructure for capacity to handle the additional flows.

10.4 Evaluation of Consumptive Uses

Some chilled water customers may have consumptive uses for a portion of the chilled water supplied. Cooling tower evaporation and blowdown, boiler blowdown, and process water use at some industries are examples of water uses which would usually result in evaporation of water rather than return to an outfall. The potential amount of water evaporated for these or other consumptive uses should be considered negligible for the following reasons:

10.4.1 Cooling Tower Evaporation

When cooling towers are operated a small percentage of the water circulated in the towers is lost to evaporation. The percentage of evaporated water is small, perhaps 1 to 3% of the circulated water flow, equating to only a few gallons per minute for medium sized buildings. More importantly, a building connected to the chilled water system would not be operating its cooling tower, but would be cooled by the chilled water supplied. For this reason, cooling tower evaporation losses do not need to be considered further.

10.4.2 Cooling Tower Blowdown

When cooling towers operate, a small portion of the circulating water is evaporated, leaving behind any dissolved solids that were present in the water. Over time, the amount of dissolved solids in the circulating cooling water rises, and can cause scaling problems with the pipes and pumping. To eliminate this problem, a small amount of water is periodically drained from the cooling tower. This is called blowdown. The blowdown is replaced with fresh supply water with low dissolved solids concentrations in order to maintain a target dissolved solids concentration. The blowdown is discharged to the sanitary sewer in most cases, and so travels to a wastewater treatment plant. As with cooling tower evaporation, blowdown does not need to be considered in this study because the amount of blowdown is small and the cooling tower will probably not be operating if chilled water is being supplied.

10.4.3 Boiler Blowdown

A small amount of water is drained from operating boilers to maintain a target dissolved solids concentration and just as with cooling towers, this item can also be removed from consideration because of its small volume.

10.4.4 Industrial Cooling

Some industrial processes evaporate water for cooling purposes. The best example of such a process is contact cooling water used to cool hot metal, resulting in the evaporation of large amounts of water. None of the high potential chilled water customers identified in this study utilize such a process.

10.5 Section Summary

The list of potential customers (Table 9-2) was refined by eliminating business entities that are too far from the locations identified for chilled water distribution. Required flow rates for the remaining potential chilled water customers are presented (Table 10-1). Water quality and other issues are addressed.

11.0 Central New York Potable Water Systems and Opportunities for Naturally Chilled Water

11.1 Section Introduction

The two main water distribution systems in the Syracuse region are described. The City of Syracuse receives most of its drinking water from Skaneateles Lake, while the neighboring communities rely on Lake Ontario and Otisco Lake for their water supply needs. The interconnections between the systems are described, and implications for Lake Ontario and Skaneateles as sources for Naturally Chilled Water are discussed.

11.2 Onondaga County and City of Syracuse Potable Water Systems

An understanding of the potable water supply systems serving the City of Syracuse and Onondaga County is needed to properly evaluate each option. The Syracuse region is served by three distinct potable water sources: one from Skaneateles Lake, one from Otisco Lake, and one from Lake Ontario (Figure 11-1). The Skaneateles Lake and Lake Ontario potable water supply systems have potential access to deep water with the low temperatures required for delivery of naturally chilled water. The Otisco Lake source accounts for about 20% of the total potable flow to the Syracuse region, does not have the possibility of a deep water intake, and will not be considered further in this report.

Potable water for the City of Syracuse has been provided by Skaneateles Lake since the late 1800s. Skaneateles Lake is at an elevation of 860 feet above sea level. Much of the City of Syracuse is at an elevation of 360 to 500 feet above sea level, allowing gravity transmission of potable water to most areas of the city. Areas of the city that are at higher elevation are served by gravity under low flow conditions and by pumping under high demand conditions.

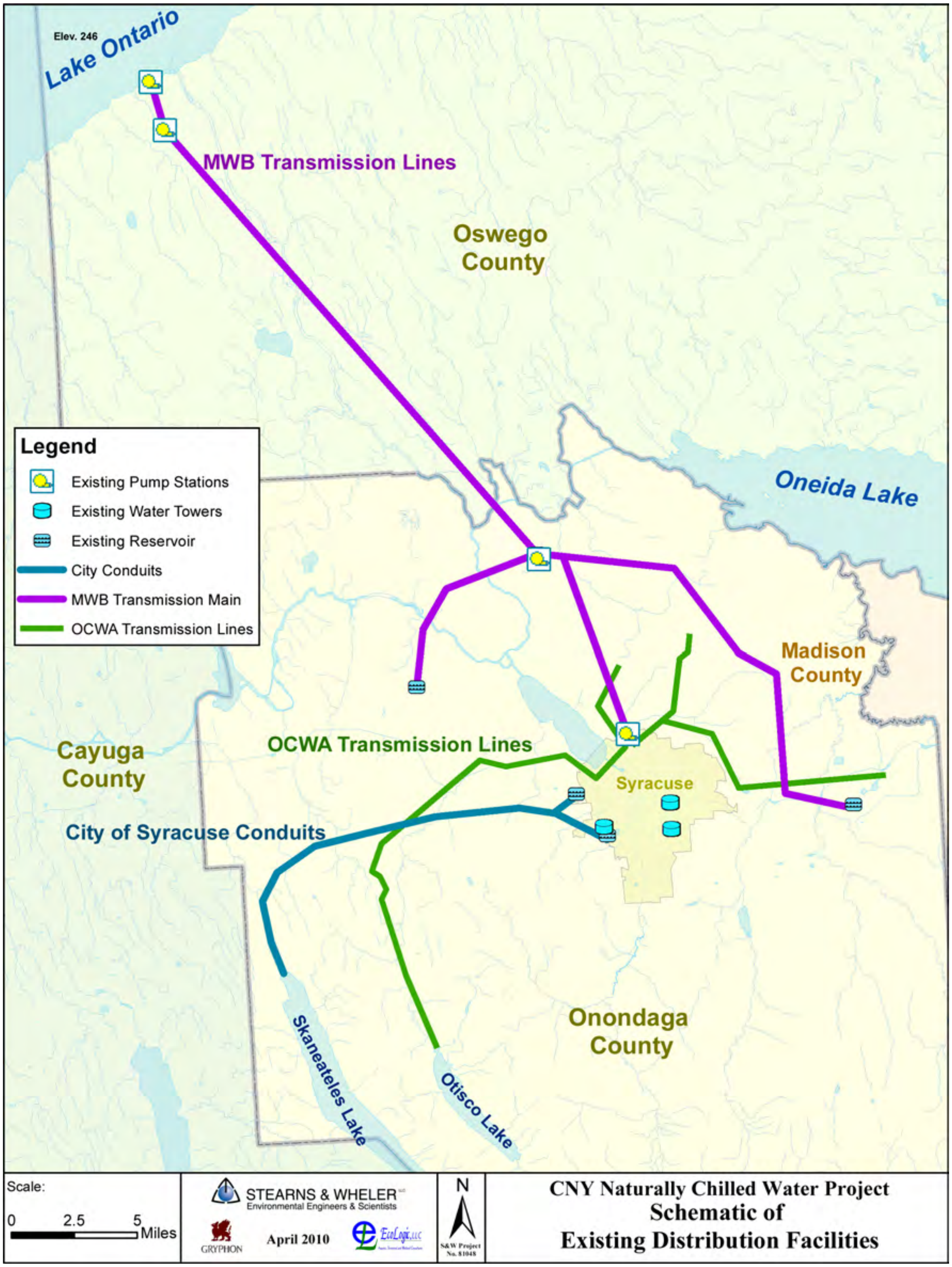
Two lake intakes and three gravity transmission conduits from the Village of Skaneateles to the City of Syracuse were constructed between 1896 and 1940 and are still the primary potable water supply systems serving the city. The potable water system is owned and operated by the City of Syracuse, which has a withdrawal permit from the New York State Department of Environmental Conservation (NYSDEC) to draw as much as 58 million gallons per day (mgd) from Skaneateles Lake. The capacity of the existing transmission conduit system varies with lake level. The transmission capacity is about 50 mgd. (Further investigation would be necessary to determine the actual hydraulic capacity of the city conduit system under all operating conditions, and is beyond the scope of this study). In recent years, the range of flow rates through the city transmission system varied from 35 to 48 mgd.

The city can also obtain some of its potable water from the Metropolitan Water Board (MWB) system which draws water from Lake Ontario through an intake in the City of Oswego, NY. The elevation of Lake Ontario is 246 feet (75 m) above sea level, so the water withdrawn must be pumped to reach the City of Syracuse. The MWB supplies water to the Onondaga County Water District through the Onondaga County Water Authority (OCWA). It also supplies the City of Syracuse, primarily as an emergency supply during periods of drought. Raw water is pumped to the MWB water treatment plant (60 mgd capacity) in Oswego where it is treated to potable water standards. Clearwater (finished water) pumps deliver the treated water to a 54-inch diameter reinforced concrete pressure transmission main for discharge to MWB's Terminal Reservoir in Clay. From Terminal Reservoir, the Farrell Road pump station delivers water to the eastern and western branches of the transmission system (serving Onondaga County) and the central branch pipeline (primarily serving the City of Syracuse). The MWB central branch transmission system enters the City from the north, with a metered connection to the city at the Seventh North Street pump station.

The MWB has a withdrawal permit for up to 62.5 mgd from Lake Ontario. The City of Syracuse purchases approximately 7 to 12 mgd of potable water from the MWB system during drought periods. This potable water enters the city distribution system at the Seventh North Street pump station, a 15 mgd booster pumping station. The city limits its purchase of water from the MWB due to hydraulic limitations in the north end of their distribution system. High pressure from the Seventh North Street booster pumping station can cause ruptures in the water distribution pipes in the city.

The withdrawal of lake water for potable use is controlled by the NYSDEC using a withdrawal permit system. The withdrawal limits noted above are based on existing, approved withdrawals as recorded by the NYSDEC Bureau of Water Resource Management. Increases to existing permitted withdrawal limits can be difficult to obtain, particularly in watersheds with strong community organization as is the case in the Skaneateles area.

Figure 11-1. Schematic of Existing Water Distribution Infrastructure in Oswego and Onondaga Counties



11.3 Potential for Central New York Naturally Chilled Water

11.3.1 Introduction

Both Lake Ontario and Skaneateles Lake are potential sources for naturally chilled water. The Lake Ontario source could supply naturally chilled but non-potable water in parallel with the existing potable water infrastructure. In this case, the chilled water system would be similar to the Cornell Lake Source Cooling system, in that potable and non-potable systems would be completely separate (see Section 3).

Either Lake Ontario or Skaneateles Lake could provide naturally chilled water through its existing potable water system infrastructure, in a system configuration similar in general to the Toronto Deep Lake Cooling System (see Section 3).

For either source water and/or system configuration, a chilled water system would include the following components.

- Intake structures at the depth necessary to withdraw naturally chilled water from either lake source.
- Water transmission pipelines to convey the naturally chilled water to a heat exchanger.
- Return pipelines to discharge water from the heat exchangers to an appropriate outfall (in the case of non-potable water) or back into the potable water system (in the case of potable water).

Chilled water customers would be served by a closed loop conveying water from the heat exchanger to users, and back to the heat exchanger. This closed loop is separate and distinct from the potable water system. Water in this loop is not potable water, and the system would be designed to prevent mixing of potable and non-potable water (See Figure 3-2 for a schematic illustrating the heat exchanger and closed loop in the Cornell system).

Initial considerations regarding these system configurations are presented below and in more detail in following sections.

11.3.2 Lake Ontario Source

For Lake Ontario, the proposed project would install a new potable water intake approximately 3.7 miles (6.1 km) into the lake to a depth that could reliably deliver water at a temperature of 41ºF to 43ºF (5.0 to 6.1ºC). The water would enter a new wet well in Oswego, and then be pumped and treated with existing MWB facilities. The treated, naturally chilled water would be pumped to a heat exchange facility located just north of the City of Syracuse at Terminal Reservoir through the existing 54-inch clearwater transmission main. A new approximately 4.5-mile (7.2 km), 36-inch diameter chilled water pipeline would be extended from this location to the former cogeneration facility at East Taylor Street and Interstate Route 81 in the City of Syracuse.

The existing clearwater transmission main from Lake Ontario could deliver up to 60 mgd based on the capacity of the MWB water treatment plant in Oswego. The pipeline has a capacity of 72 mgd and the daily average potable water consumption is 22 mgd. The project could limit its size to match that of Skaneateles for a comparison of costs. This would require only 30 mgd of naturally chilled water from Lake Ontario.

11.3.3 Skaneateles Lake Source

For Skaneateles Lake the proposed project would install a new potable water intake approximately 3.7 miles (6.0 km) into the lake to a depth that could reliably deliver water at a temperature of 41-43ºF (5 - 6.1ºC). The water would enter a new wet well in the Village of Skaneateles and be delivered to a location just west of the City of Syracuse through existing city transmission conduits. A new heat exchange facility constructed at that location would transfer thermal energy into a 36-inch diameter chilled water transmission piping loop which would be extended to chilled water customers in the City of Syracuse.

It is anticipated that the existing conduits from Skaneateles to Syracuse could reliably deliver 30 mgd of naturally chilled water through gravity flow to a new heat exchange facility. The hydraulic design flow assumption of 30 mgd would limit the available cooling capacity of the system unless other system components were upgraded. To maintain the current hydraulic design capacity of 58 mgd, construction of new infrastructure including additional intake(s), transmission lines, outfalls, and chilled water loops would be required. This expansion would likely be deemed infeasible and growth in capacity would ultimately be limited to allow additional water extraction from Skaneateles Lake. Growth in cooling demand could be addressed through the use of thermal storage or new chillers in the future.

11.3.4 Heat Exchanger

In either case (Lake Ontario or Skaneateles Lake source water), a closed loop would be used to pump naturally chilled (non-potable or potable, depending on system configuration) water to a new Heat Exchange Facility.

The Heat Exchange Facility would utilize heat exchangers designed to prevent contact between potable and non-potable water, as similar to but more elaborate than previously described in the discussion of the Toronto Deep Lake Chilled Water System (Section 3). The non-potable water from the heat exchangers would circulate into a chilled water loop that would be extended to chilled water customers, including University Hospital, Crouse Irving Hospital, Upstate Medical Center and SUNY ESF. The chilled water loop piping would be 36-inches in diameter.

The expected flow of 30 mgd translates into approximately 13,000 tons of cooling with a temperature rise of 15ºF (9.4ºC). This equates to approximately 20 million ton-hrs. of cooling available on an annual basis. The Syracuse University campus and nearby hospitals have a current annual cooling load of approximately 18 million ton-hrs.

The cooling capacity of the proposed NCW Project would place the existing conventional chillers for the users defined above on standby, as chillers would only be required to meet cooling loads for critical customers in the event that the naturally chilled water system is out of service. As a result, the existing conventional chillers at the University and hospitals would likely have to be maintained on a regular basis.

For the base case analysis, 0.9 kW/ton electrical energy consumption was utilized for the electric chillers, ancillary equipment, and distribution pumps. This number could be refined through a more detailed analysis of the anticipated users existing and proposed cooling equipment.

For the Naturally Chilled Water Project case, chilled water production electricity consumption has been estimated to be 0.10 kW/ton. Implementation of a NCWP would result in an energy savings of approximately 12 million kW-hrs of electricity per year and an energy cost savings of approximately $1.44 million a year at present electric rates.

11.4 Environmental Consequences Due to Chilled Water Use

Any business or industry which switches from the use of mechanical chillers to chilled water will change both electrical consumption and environmental emissions. The switch to chilled water would also cause the following changes:

1 A reduction in heat emitted to the atmosphere near the building. The cooling provided by mechanical chillers results in heat being emitted to the local atmosphere via cooling towers or air cooled condensers. These heat emissions add to the urban heat sink in the downtown area, and would be significantly reduced by buildings using chilled water. The heat rejected in a chilled water system is sent out in the warmed water, and is not added to the environment immediately surrounding the building.

2 A reduction of the amount of potable water currently used for cooling tower evaporation and blowdown.

3 A reduction in the amount of water treatment chemicals used in the cooling tower systems.

4 A reduction in the total amount of electricity generated to drive mechanical chillers. This reduction would occur at electrical generating stations around the Central New York area, and would have the following effects at each station:

- A reduction in the amount of fossil fuels burned
- A reduction in air pollutant emissions
- A reduction in cooling water use
- A reduction water treatment chemicals used in the cooling tower systems
- A reduction in heat emissions to the atmosphere

11.5 Section Summary

The Syracuse region has two water sources capable of supplying Naturally Chilled Water to local users: Lake Ontario and Skaneateles Lake. Each source currently supplies different parts of Onondaga County with potable water (Figure 11-1) and each source is subject to withdrawal limits dictated by existing permits and other constraints. Water from Lake Ontario is pumped to the region, while Skaneateles Lake water flows to the region by gravity. Both sources are excellent sources of potable water to the region. Each source is capable of providing 30 mgd of naturally chilled water without compromise in either quantity or quality to the existing potable water systems.

12.0 Ecological Issues Related to System Design: Source Water

12.1 Section Introduction

In this section, we consider a subset of the possible environmental consequences of a Naturally Chilled Water (NCW) system. The potential environmental impacts and recommendations for prevention contained in this section relate to the conceptual design of the chilled water intake structure(s) and piping, and associated water treatment measures. Preliminary environmental considerations are presented here; several components are discussed in further detail in later sections of this feasibility study.

12.2 Local Effects and Distance of Effect of Intake Structures

Local effects may result from impingement and entrainment. These will be influenced by: (1) the Approach Velocity, which refers to the water velocity component perpendicular to and approximately three inches in front of the screen face, and (2) the Sweeping Velocity, which describes the water velocity component parallel and adjacent to the screen face. Approach velocity is considered to be of primary importance in reducing fish loss at intakes, and regulatory agencies focus on approach velocity in their effort to protect vulnerable fish populations (Peake 2004). The USEPA requires that the approach velocity be no more than 0.15 meters per second (USEPA 2000). In addition, the effects of installation (dredging, turbidity) and thermal changes (near-field and lake-wide) could affect conditions in Lake Ontario. Cornell University's lake source cooling team determined that these problems were negligible in Cayuga Lake (Cornell University 1998). The biological/ecological impacts of thermal changes to Lakes Onondaga and Ontario cannot be assessed until the actual thermal change is determined; therefore, this subtask requires further inquiry. A summary of short and long term environmental impacts is listed in Table 12-1.

Table 12-1. Short and Long Term Environmental Impacts

Nature of Impact	Description
Short-Term Impacts (Construction Related)	Turbidity from sediment excavation (local effect)
	Littoral zone perturbed during construction (local effect)
Long-Term Impacts (Operation Related)	Potential lake wide thermal impacts are probably negligible but need to be assessed.
	Approach and sweeping velocities may cause impingement/entrainment and potential effects to populations of fish and invertebrates (local effect and lake wide?)
	Potential transfer of invasive organisms and microbes to the receiving water

12.3 Impingement and Entrainment of Aquatic Organisms

To address concerns regarding thermal pollution, and loss of aquatic life, Section §316 was included in the United States Environmental Protection Agency's (USEPA) Clean Water Act. Section §316(a) addresses thermal discharges and the effect on the receiving water body. Section §316(b) requires that the location, design, and approach velocity of cooling water intake structures reflect the Best Technology Available (BTA) for minimizing adverse environmental impact of impingement and entrainment.

Impingement occurs when aquatic organisms are trapped against end-of-pipe screens by the force of the water passing through the intake pipe. Impingement can result in starvation, exhaustion, and asphyxiation of an organism (USEPA 2000). Entrainment is the passage of fish or other organisms into an intake pipe. The approach velocity of an intake affects the swimming ability of fishes, which can in turn influence their ability to avoid impingement and entrainment. Approach velocity refers to the water velocity component perpendicular to and approximately 7.6cm (3 inches) in front of the screen face; the USEPA requires that the approach velocity be no more than 0.15 meters per second (.5 ft/s) to minimize the risk of entrainment or impingement.

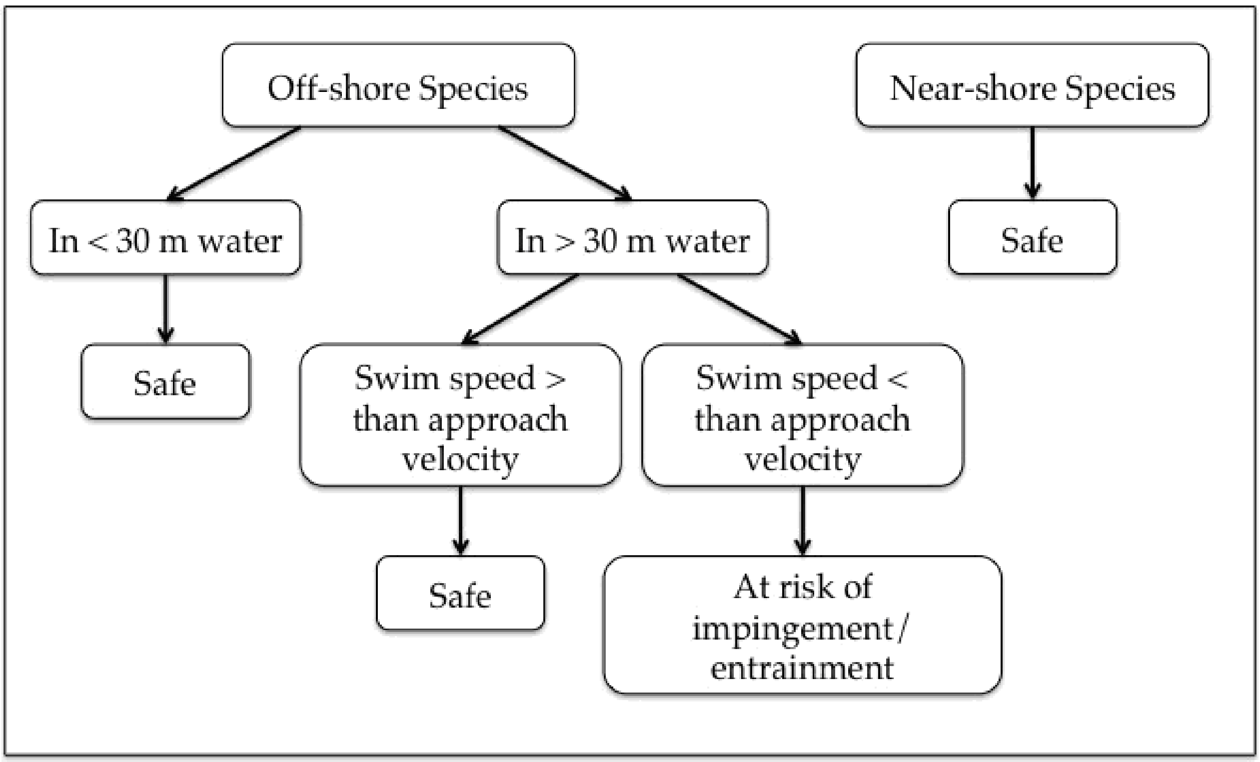
It is essential that the cooling water intake structure be designed to minimize risk to aquatic species of impingement and entrainment, taking into account design materials, organism swim speeds, and approach velocities. Table 12-2 refers to findings of LSC studies relative to impingement and entrainment of aquatic organisms.

Table 12-2. Findings of Cornell University, Enwave Energy Corporation in Toronto, Ontario, and Kodak Corporation in Rochester, NY Related to Their Environmental Impact Studies of Impingement and Entrainment

Facility	Findings
Cornell University Facilities and Services Utilities and Energy Management Cornell University, Ithaca, NY	*Mysis relicta* have a vertically layered patchy distribution in Cayuga Lake, yet can be found at the depth and location of intake pipe. This renders them potentially vulnerable to high velocity internal currents and light bulb failure. If entrained, they would be killed by the pumps and heat exchangers. However, the Environmental Impact Statement concludes that LSC is not a significant threat to *Mysis relicta* populations (Cornell University, 1998, Section 2.3.4). In the winter and spring when the demand for cooling is low (but not from June-November when the lake is thermally stratified and the demand for cooling is high), alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordox*) may be found near the intake. Published reports of swim speeds suggest that these fishes would have the capacity to avoid the intake and that there would be no adverse impact to the fish community (Cornell University, 1998, Section 2.3.7).
Toronto, Ontario, Canada	The Environmental Impact Statement will need to be obtained and reviewed.
Lake Water Cooling Project Webster, NY	Construction of a 10m x 10m x 5m intake crib was proposed for the end of the intake pipe to minimize entrance velocities to mitigate fish entrainment (Lake-Water Cooling Project Webster, New York).

To determine the risk of impingement and entrainment of fish and invertebrates in Lake Ontario and Skaneateles Lake we conducted a literature search using several databases and information sources. We suggest that some species are at risk of some level of impingement or entrainment because at least one of their life history stages overlaps with the end of the intake pipe. Based on previous studies of similar projects (Table 12-2), we would not anticipate the loss of aquatic organisms to be significant enough to be of concern as long as the appropriate screen and approach velocities are implemented at the intake. However, potential impact to species that are listed as "threatened" or "special concern" in New York State should be considered.

Figure 12-1. Decision-making Process in Assessing Impingement Risk



Using a decision tree (Figure 12-1), the species we found to be at potential risk of impingement/entrainment are: ten fish species (alewife (*Alosa pseudoharengus*), burbot (*Lota lota*), cisco (*Coregonus artedi*), deepwater sculpin (*Myoxocephalus thompsonii*), lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*), ninespine stickleback (*Pungitius pungitius*), round whitefish (*Prosopium cylindraceum*), sea lamprey (*Petromyzon marinus*), slimy sculpin (*Cottus cognatus*)) and two invertebrates (opossum shrimp (*Mysis relicta)*, and the bloody red shrimp (*Hemimysis anomala)*). The New York State Department of Environmental Conservation (NYSDEC) lists the deepwater sculpin and the round whitefish as endangered in NYS. The NYSDEC defines endangered as organisms in imminent danger of extirpation/extinction. Waters that harbor these fish require special consideration when considering construction of any large structure.

12.3.1 Review of screen types

A review of the USEPA Clean Water Act, section 316(b) led us to recommend wedge wire screen as an end-of-intake pipe technology. The ends of each pipe should be enclosed with approximately 68 m^2 (732 ft^2) of wedge wire screen to minimize the risk of entrainment to aquatic organisms. The effectiveness of the screen depends on several biological and physical factors, among them the swimming ability of the organism which for fish is dependent upon species, size, stamina, developmental stage, migratory stage (Zydlewski and Johnson 2002), and the abundance and distribution of organisms near the intake (Department of Fisheries & Oceans 1995).

While the USEPA (CWA §316 (b)) assumes new facilities will install cylindrical wedge wire screen, or fish return systems on traveling screens, it states that there are other potentially effective design technologies for minimizing adverse environmental impacts at cooling water intake structures. Table 6-4 lists possible alternatives. In addition, the USEPA reports that technologies such as fine and wide-mesh wedge wire screens, as well as aquatic filter barrier systems have been shown to reduce mortality from impingement by up to 99 percent or greater compared with conventional once-through systems. Wedge wire screens with slot sizes of 1, 2, and 3 millimeter were studied by the State of Maryland at the Chalk Point Station. One-millimeter screens led to 80 percent exclusion of all species, including larvae.

Table 12-3. Fish and Invertebrate Species Habitats That Overlap with the Intake End-of-Pipe

Common Name	Scientific Name	Status in Northeast	Adult Habitat	Spawning Habitat	Present in Lake(s)	Life Stage in Area of Intake
Alewife	*Alosa pseudoharengus*	Non-Listed	Lakes, pelagic to 100 m	Sand and gravel, shallow water	Ontario and Skaneateles	Adult
Burbot	*Lota lota*	Non-Listed	Cold, deep water of large lakes and rivers	Sandy bottom, deep water, lakes and rivers, eggs scattered and demersal	Ontario	Adult
Cisco	*Coregonus artedi*	Non-Listed	Cool lakes, below the thermocline (deep), tolerant of turbidity	Shallow water in cold lakes, broadcast spawner in open water or near substrate	Ontario and Skaneateles	Adult and juvenile
Deepwater sculpin	*Myoxocephalus thompsonii*	Endangered (NY)	Deep water, large lakes, from 70-100 m	Deep water; nest builder	Ontario	All life stages
Lake trout	*Salvelinus namaycush*	Non-Listed	Cold, well-oxygenated, deep water of lakes	At or near rocky bottom of deep water lakes or open water offshore; broadcast spawners	Ontario and Skaneateles	All life stages
Lake whitefish	*Coregonus clupeaformis*	Non-Listed	Cold water in lakes; below the thermocline in summer	Shallow water nearshore, rocky or sandy bottom	Ontario and Skaneateles	Adult and juvenile
Longnose sucker	*Catostomus catostomus*	Non-Listed	Cool, clear, deep lakes; usually shallow water	Gravel bottom of fast-flowing streams; broadcast spawner	Ontario and Skaneateles	Adult
Ninespine stickleback	*Pungitius pungitius*	Non-Listed	Cool, quiet waters; occurs up to 110 m	Nearshore and shallow waters; nest builder in rocky or muddy areas	Ontario	Adult and juvenile
Round whitefish	*Prosopium cylindraceum*	Endangered (NY)	Deep, cold, clear lakes; opportunistic bottom feeder but usually ventures no deeper than 50 m	Gravel bottom, shallow shoals or mouths of stream; broadcast spawner	Ontario	Adult

Table 12-3. Fish and Invertebrate Species Habitats That Overlap with the Intake End-of-Pipe (Continued)

Common Name	Scientific Name	Status in North-east	Adult Habitat	Spawning Habitat	Present in Lake(s)	Life Stage in Area of Intake
Sea lamprey	*Petromyzon marinus*	Non-Listed	Lakes, cold deep water below thermocline	Gravel bottom in streams and rivers; anadromous	Ontario	Adult
Slimy sculpin	*Cottus cognatus*	Non-Listed	Deep oligotrophic lakes and cold headwater streams	Streams under rocks or logs; deep water in lakes; nest builder	Ontario and Skaneateles	All life stages
Bloody red shrimp	*Hemimysis anomala*	Non-Listed	Found to 50 m on hard bottom; can survive warm or cold tempera-tures	Mating in spring; benthic; eggs brooded	Ontario	All life stages
Opossum shrimp	*Mysis relicta*	Non-Listed	Deep, cold, oligotrophic and mesotrophic lakes, summer in hypolimnion	Eggs released December to August to the water column	Ontario and Skaneateles	All life stages

Table 12-4. Technologies Used to Minimize Impingement and Entrainment (USEPA, 2000)

Type of Intake Technology	Examples
Intake screen systems	Single-entry, single-exit vertical traveling screens; modified traveling screens (Ristroph screens); single-entry, single-exit inclined traveling screens; single-entry, double-exit vertical traveling screens; double-entry, single-exit vertical traveling screens (dual-flow screens); horizontal traveling screens; fine mesh screens mounted on traveling screens; horizontal drum screens; vertical drum screens; rotating disk screens; and fixed screens
Passive intake systems	Wedge wire screens, perforated pipes, perforated plates, porous dikes, artificial filter beds, and leaky dams
Diversion or avoidance systems	Louvers, velocity caps, barrier nets, air bubble barriers, electrical barriers, light barriers, sound barriers, cable and chain barriers, aquatic filter barrier systems, and water jet curtains
Fish handling systems	Fish pumps, lift baskets, fish bypasses, fish baskets, fish returns, fish troughs, and screen washes
Intake crib	Constructed at end of pipeline to minimize entrance velocities to mitigate fish entrainment (Lake-Water Cooling Project Webster, NY)

12.4 Invasive Species Considerations

"Lake-source cooling" or "deep lake water cooling," uses water pumped from the depths of adjacent lakes or oceans to cool municipal buildings. The water in turn is either used as drinking water or is returned to the source water body. The Central New York Naturally Chilled Water Project proposes to take water either from Skaneateles Lake or Lake Ontario. Depending upon system configuration, the water would be returned to the drinking water supply system, with excess water routed to reservoirs and possibly discharged to Onondaga Lake, one of its tributaries, or tributaries to the Oneida River, all of which are in the Lake Ontario drainage basin. This presents planners and managers with a unique situation: taking water from one body and returning it to another. This situation may facilitate the transfer of aquatic organisms from one water body to the next, requiring that the effect of exotic invasions be considered.

The biology of many microorganisms facilitates invasion: asexual reproduction; dormant resting stages; tolerance to broad environmental conditions and; high density (Ruiz et al. 2000a). Examples of known microbes causing disease in the Great Lakes, but not yet in Onondaga Lake include:

- *Vibrio cholerae*, which causes cholera, an acute diarrheal disease. A study done in the Chesapeake Bay found Vibrio cholerae in plankton samples from all ships sampled, and 2 serotypes of the disease in 93% of all ships (Ruiz et al. 2000b).
- Type E botulism, a rare, but serious paralytic illness caused by *Clostridium botulinum*. Zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*) filter water and deplete benthic oxygen through their respiration, creating an anaerobic environment suitable for the bacterium to thrive (Rodman and Bowser 2006). Type E botulism affects fish and birds that eat mussels, and birds that eat fish that have eaten mussels. In eastern Lake Ontario in November 2007, more than 100 loons died from Type E botulism (NYSDEC).
- Viral Hemorrhagic Septicemia, a disease caused by a virus that affects marine and freshwater fish caused by the Type IVb strain of the VHS virus. More than 50 fish species in the northern hemisphere are susceptible, and the DEC and Animal and Plant Health Inspection Service have placed restrictions on fish sales and transport to avoid spread of VHS (NYSDEC 2009; USDA 2007).

To characterize the invasive fish and invertebrate species in Lake Ontario with respect to their potential for entrainment, their status in Onondaga Lake, and their potential survivability in Onondaga Lake, we did a literature search using several scientific databases.

A subset of invasive invertebrate and fish species in Lake Ontario are listed in Table 12-5 along with their potential for entrainment in the pipe, and ability to survive in Onondaga Lake based on thermal and other habitat requirements. The prevalence of invasive organisms is much less in Skaneateles Lake than Lake Ontario. Additionally, any invasive species that has been encountered in Skaneateles Lake has also been documented in Lake Ontario.

Refer to Section 22 for a more complete treatment of the problem of invasive species in the Lake Ontario drainage basin.

Table 12-5. Invasive Fish and Invertebrate Species in Lake Ontario

Species - Common Name	Scientific Name	Potential for Entrainments	Potential for Survival in Onondaga Lake
Alewife	*Alosa pseudoharengus*	+	@
Bloody red shrimp	*Hemimysis anomala*	+	+
Blueback herring	*Alosa aestivalis*	+	+
Bluespotted sunfish	*Enneacanthus gloriosus*	-	+
Common carp	*Cyprinus carpio*	-	@
Fishhook waterflea	*Cercopagis pengoi*	-	@
Goldfish	*Carassius auratus*	-	@
Margined madtom	*Noturus insignis*	-	?
Round goby	*Neogobius melanostomus*	-	+
Rudd	*Scardinius erythrophthalmus*	-	@
Sea lamprey	*Petromyzon marinus*	+	@
Spiny waterflea	*Bythotrephes longimanus*	+	-
White perch	*Morone americana*	-	@
Zebra and quagga mussels	*Dreissena polymorpha and D. rostriformis bugensis*	+	@
Notes: @ = currently present in Onondaga Lake; +/- = More likely/Less likely			

12.5 Design Issues Related to Invasive Species

Biofouling is the gradual accumulation of waterborne organisms (such as bacteria and protozoa) on the surfaces of structures in water; it contributes to corrosion of the structures and to a decrease in the efficiency of moving parts. Ideally invasive organisms and organisms contributing to biofouling may be treated concurrently. Therefore, it was important to determine the best treatment options for the intake pipe and cooling water. We conducted a literature search using several scientific databases. Treatment options commonly used are summarized in Table 12-6.

Table 12-6. Summary of Commonly Used Treatment Options for Pipe or Water

Control	Mechanical or Chemical	Mode of Action	Advantages	Disadvantages
Biocides	Chlorobromine, non-oxidizing biocides, asphyxia, paints, non-toxic coatings	Target cell function	OK in correct combination, concentration, dosage, frequency	None is universal, resistance
Chlorination	Continuous or intermittent chlorination at concentrations varying from 1 to 3 mg/l	Destructive nonselective oxidant, membrane agent, stops ATP production	Cost-effective, easy application, familiarity of use, proven reliability	By-products include chloroform, chlorine residual disappears quickly therefore re-growth allowed, resistance
Coatings	Most coatings contain a metal (copper or tin) or another substance (i.e., a polymer) to make it hard for veliger (molluscan larval stages) to cling to surface.	Retards biofilm	Efficient in conjunction with high water velocity, many non-toxic	Existing pipes are often inaccessible, local failure; may not kill viruses or bacteria. Requires maintenance
Dispersants	Surfactants, emulsifiers, synthetic water-soluble polymers	Disperse sessile microbial populations into the bulk water, reduce cell permeability	Synthetic, can be made to any molecular weight, not easily degraded by biological organisms, does not react to chlorine or iron salts, cost effective	More effective in conjunction with biocides

Table 12-6. Summary of Commonly Used Treatment Options for Pipe or Water (Continued)

Control	Mechanical or Chemical	Mode of Action	Advantages	Disadvantages
Enzymes	Proteases, hydrolases, glycosidases, lipases	Break down polysaccharide matrix to prevent attachment	Prevents adhesion and removes adhered bacterial cells effectively	Increases bacterial adhesion, depending on enzymatic concentrations and the type of enzymes tested
Filtration	Microfiltration <0.1 mm	Excludes organisms	Not introducing foreign substances into the system	Clogging, costs.
Ice nucleation	Heat exchanger is frozen	Ice crystals physically dislodge biofilm	Not introducing foreign substances into the system	Must be repeated more than once; may not kill all viruses or bacteria
Mechanical	Thermal shock, pulses of high-speed water, freshwater injection, abrasive balls, brushes, acoustic energy, flow inversion	Physically dislodge biofilm	Best with high-level intermittent chlorine, flow inversion can eliminate mature biofilm	Some of these methods require taking the system offline
Ozonation	Disinfectant/oxidant	Strong oxidant	As ozone decomposes it generates intermediates with greater oxidizing power than ozone	Unstable in water, reacts with organic substances to form by-products that are more biodegradable than precursors, no on-site storage, expensive

Table 12-6. Summary of Commonly Used Treatment Options for Pipe or Water (Continued)

Control	Mechanical or Chemical	Mode of Action	Advantages	Disadvantages
Pigging	Cleaning distribution lines by inserting a device known as a pig into the lines and pushing it through	Physically dislodge biofilm	Not introducing foreign substances into the system	Limited to pipes of constant diameter, not effective with sharp, short radius bends, not a permanent solution; does not kill viruses or bacteria
Ultraviolet light (UV)	High energy photons in the 200-300 nm range	Destroys DNA, RNA	Effective in reducing the population of microfoulers from already developed biofilms	Treats small quantities of water, water must be low in iron and turbidity, expensive, difficult to achieve complete disinfection

12.5.1 Organism Survival in Pipe With Treatment Options

The approximate 40-mile (64 km) or 23-mile (37 km) journey through the pipeline from Burt Point or Skaneateles Lake, respectively to Syracuse, NY, in addition to appropriate treatment measures, will most likely make it difficult for many species that made it into the pipe to survive the journey. However, *Dreissena polymorpha* and *D. bugensis* are known biofouling agents in intake pipes, and their veligers could be entrained. *Mysis relicta* and *Hemimysis anomala* are small enough and weak enough to become entrained in the pipe.

We cannot determine which, if any, of these species would potentially live in the outflow water until we know for certain which treatment option will be employed. A study of continuous chlorination at 1 mg/L caused 100% mortality of *D. polymorpha* in 588 hours, and little or no mortality in the same time at intermittent application of the same concentration (Rajagopal et al. 2003). This highlights the importance of continuous treatment.

The biology of many microorganisms facilitates invasion and propagation, e.g. high fecundity, asexual reproduction, dormant resting stages, tolerance to broad environmental conditions, and presence in high numbers (Ruiz et al. 2000b). Therefore, special attention should be paid to microbes, which are understudied, and so we have little or no information on many of them. The presence of (1) Cholera (*Vibrio cholerae*), (2) Type E botulism (*Clostridium botulinum*), and (3) VHSV (Viral hemorrhagic septicemia virus) has been documented in Lake Ontario. This highlights the importance of continuous treatment to avoid spreading known or unknown disease-causing microorganisms.

12.5.2 Review of the Likelihood of Treatment Failure (Linked To Invasives)

This sub-task requires further inquiry; there is not enough publicly available information to address it at this time. This issue is critical because in most chilled water systems the water is returned to the same body of water, and so treatment is meant primarily to reduce clogging in the pipe itself. In the case of the NCW project, water would be returned to a different receiving body, and so there is greater potential for spread of organisms (including disease-causing micro-organisms).

12.6 Section Summary

The life histories of aquatic species in Lake Ontario and Skaneateles Lake likely to be affected by a deep water intake are reviewed (Table 12-3). Methods and techniques to minimize effects to these aquatic species are reviewed (Table 12-4). The issue of invasive species was addressed in a preliminary fashion (Sections 12-4, 12-5 and Table 12-5); this important issue is discussed more thoroughly in Section 22.

12.7 Literature Cited

Cornell University. 1998. Environmental Impact Statement: Lake Source Cooling. Cornell University Facilities Services Utilities and Energy Management. Retrieved October 2009: http://www.utilities.cornell.edu/utl_lsceis_toc.html.

Department of Fisheries and Oceans. 1995. Freshwater Intake End-of-Pipe Fish Screen Guideline. Ottawa, Ontario K1A OE6.

New York State Department of Environmental Conservation (NYSDEC). 2009. Viral Hemorrhagic Septicemia (VHS) in New York. Retrieved October 2009 from: http://www.dec.ny.gov/animals/25328.html.

Peake, S. 2004. Effect of approach velocity on impingement of juvenile northern pike at water intake screens. North American Journal of Fisheries Management 24: 390-396.

Rajagopal, S., G. Van der Velde, M. Van der Gaag, and H. Jenner. 2003. How effective is intermittent chlorination to control adult mussel fouling in cooling water systems? Water Research 37: 329-338.

Rodman, G., and P. Bowser. 2006. Ecology of Type E botulism within Dreissenid beds. Digest of Aquatic Invaders National Aquatic Nuisance Species Clearinghouse vol. 17 no. 2.

Ruiz G.M., T.K. Rawlings, F.C. Dobbs, L.A. Drake, T. Mullady, A. Huq, and R.R. Colwell. 2000a. Worldwide transfer of microorganisms by ships. Nature 408: 49-50.

Ruiz G.M., P. Fofonoff, J.T. Carlton, M.J. Wonham, and A.H. Hines. 2000b. Invasions of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases. Annual Review of Ecology and Systematics 31: 481-531.

United States Department of Agriculture (USDA). 2007. Questions and answers about the VHS Federal Order. Animal and Plant Health Inspection Service Factsheet January 2007.

United States Environmental Protection Agency (USEPA). Clean Water Act. U.S. Code. Title 33, Section 1314. U.S. Environmental Protection Agency, Washington, DC.

United States Department of Environmental Protection (USEPA). 2000. National Pollution Discharge Elimination System: Cooling Water Intake Structures for New Facilities; Proposed Rules. Volume 65: 49060-49121.

Zydlewski, G., and Jeffrey Johnson. 2002. Response of Bull Trout Fry to Four Types of Water Diversion Screens. North American Journal of Fisheries Management 22: 1276-1282.

13.0 Conceptual Schematics: Options 1-5

13.1 Section Introduction

The original project concept considered a single deep water intake in Lake Ontario and a lake water transmission pipeline from the City of Oswego to the City of Syracuse. Project team discussions early in the study resulted in recognition that a significant volume of potable water was already traveling near to and into the City of Syracuse each day, and that thermal harvesting of the potable water system could provide a significant benefit without installing additional transmission systems. Further discussion led to the investigation of several options for delivering a large amount of naturally chilled water to the City of Syracuse. A total of five options[1], which included drawing cold water from either Lake Ontario or Skaneateles Lake were developed:

Option 1: Original Concept - Lake Ontario intake with new (non-potable water) transmission pipeline, heat exchange facility in the city, outfall to Onondaga Lake.

Option 2: Lake Ontario intake utilizing existing Metropolitan Water Board pipeline segments; heat exchange facility near Terminal Reservoir.

Option 3: Lake Ontario intake utilizing existing Metropolitan Water Board pipeline segments; heat exchange facility near Seventh North Street.

Option 4: Skaneateles Lake intake utilizing existing city pipeline segments; heat exchange facility near Westcott Reservoir.

Option 5: Skaneateles Lake intake utilizing existing city pipeline segments, with a connection to potable water from Lake Ontario.

This section presents initial descriptions and schematics for each of the five options considered.

13.2 Option 1 - Lake Ontario; New Pipeline

This is the original project concept and considers a new deep water intake, pumping station, transmission pipeline from City of Oswego to the City of

1. The five options are shown schematically in Figures 13-1 through 13-5 later in this section.

Syracuse along the existing MWB right of way, heat exchanger, and chilled water loop to serve customers in the University Hill area. The raw water from the new deep water intake would **not** be treated to potable standards and would remain completely separate from the existing potable water system. Treatment would be provided for protection from invasive species only. After thermal harvesting, the lake water would discharge to Onondaga Lake via a new outfall.

13.3 Option 2 - Lake Ontario; Shared Use of Existing MWB Clearwater Transmission Main, Heat Exchanger Near Terminal Reservoir

This option considers the shared use of existing infrastructure where available and adds new components where needed. New components would include a deepwater intake and pumping station, a heat exchange facility, and a chilled water loop. Existing infrastructure to be shared includes the MWB treatment plant and clear water pumping station in Oswego and the clear water[1] transmission main from the treatment plant to Terminal Reservoir. The lake water would be treated to potable standards at the MWB treatment plant, and travel through the MWB clearwater transmission main to a new heat exchange facility near Terminal Reservoir. After thermal harvesting, the water would enter Terminal Reservoir for distribution to potable customers through the existing distribution system. If chilled water demand exceeds potable water demands, excess flow would be discharged to a local water body.

13.4 Option 3 - Lake Ontario; Shared Use of Existing MWB Clearwater Transmission Main, Heat Exchanger Near Seventh North Street

This option considers the shared use of existing infrastructure where available and adds new components where needed. New components would include a deepwater intake and pumping station, a transmission segment parallel to the MWB Central Branch, a heat exchange facility located in the City of Syracuse near Seventh North Street, and a chilled water loop. Existing infrastructure to be shared includes the MWB treatment plant and clear water pumping station in Oswego and the clear water transmission main from the treatment plant to Terminal Reservoir. As with Option 2, the lake water would

1. Clear water = water after treatment to potable water standards.

be treated to potable standards at the MWB treatment plant and travel through the MWB clear water transmission main and the new transmission main to a new heat exchange facility near the existing Seventh North Street pump station. After thermal harvesting, the water would be pumped through a new transmission pipeline along the New York State Thruway to enter the MWB transmission system where the Eastern Branch crosses the Thruway. If chilled water demand exceeds potable water demands, excess flow would be discharged to a local water body.

13.5 Option 4 - Skaneateles Lake; Shared Use of Existing City Transmission Conduits

This option considers a new deepwater intake, pumping station, and heat exchanger, while sharing use of much of the existing three-conduit transmission system from Skaneateles to the City of Syracuse. New components would include a deepwater intake and pumping station near the existing Skaneateles intakes, a heat exchange facility located near Andrews Gatehouse, and a chilled water loop. Existing infrastructure to be shared includes the city conduit system from Skaneateles to Andrews Gatehouse, and the chemical treatment facilities to disinfect the water as it enters the conduit system. The lake water would travel through the conduit system to the new heat exchanger near Andrews Gatehouse. After thermal harvesting, the water would be returned to the transmission conduits and enter the Woodland/Westcott Reservoir system for distribution to city customers.

13.6 Option 5 - Skaneateles Lake; Shared Use of Existing City Transmission Conduits, Connection to Lake Ontario

This option is similar to Option 4 in most respects. The significant difference is that potable water flow from Skaneateles Lake would be set at a constant 30 mgd under normal operating conditions. This amount of water from the deep water intake would provide for the anticipated cooling requirements of the large city users, and all of the water would be used for potable purposes after thermal harvesting. Additional potable water required by the city above 30 mgd would be provided from the existing Lake Ontario intake and MWB distribution system. A new connection from the MWB Western Reservoir to a location near the Westcott Reservoir would be constructed as a part of this option, and would provide redundancy to the Skaneateles water supply.

Figure 13-1. Schematic of Naturally Chilled Water - Option 1

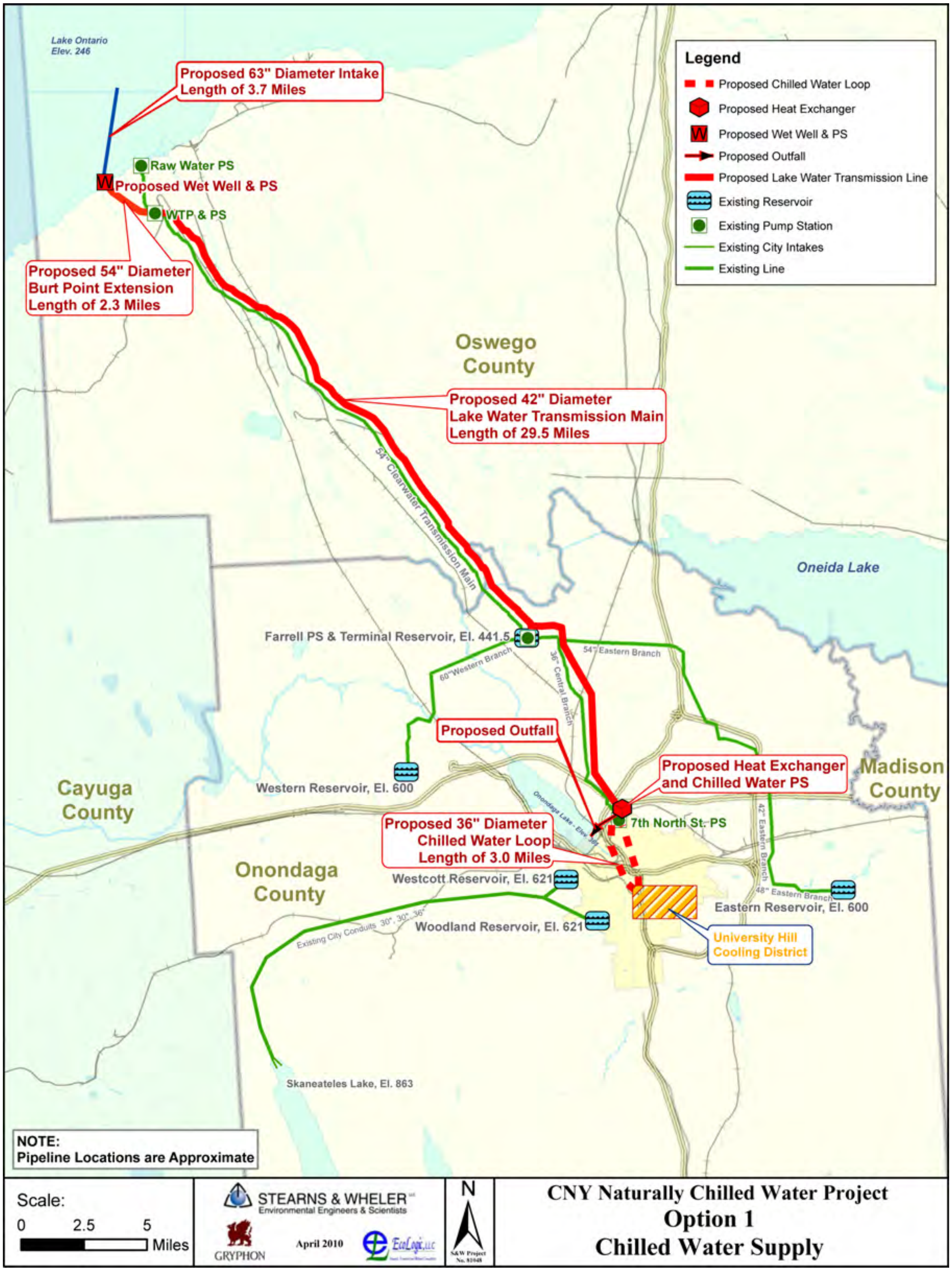


Figure 13-2. Schematic of Naturally Chilled Water - Option 2

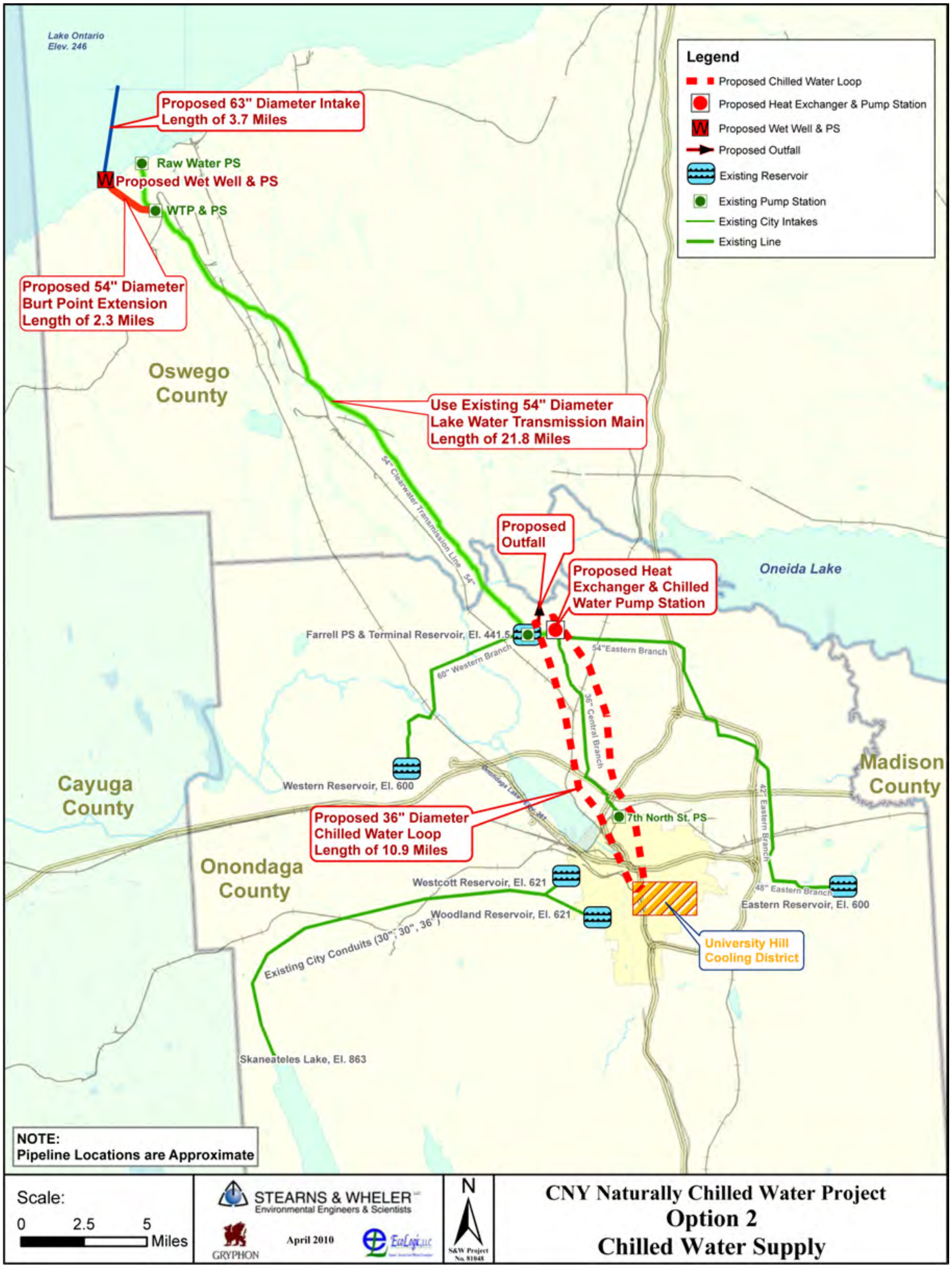


Figure 13-3. Schematic of Naturally Chilled Water - Option 3

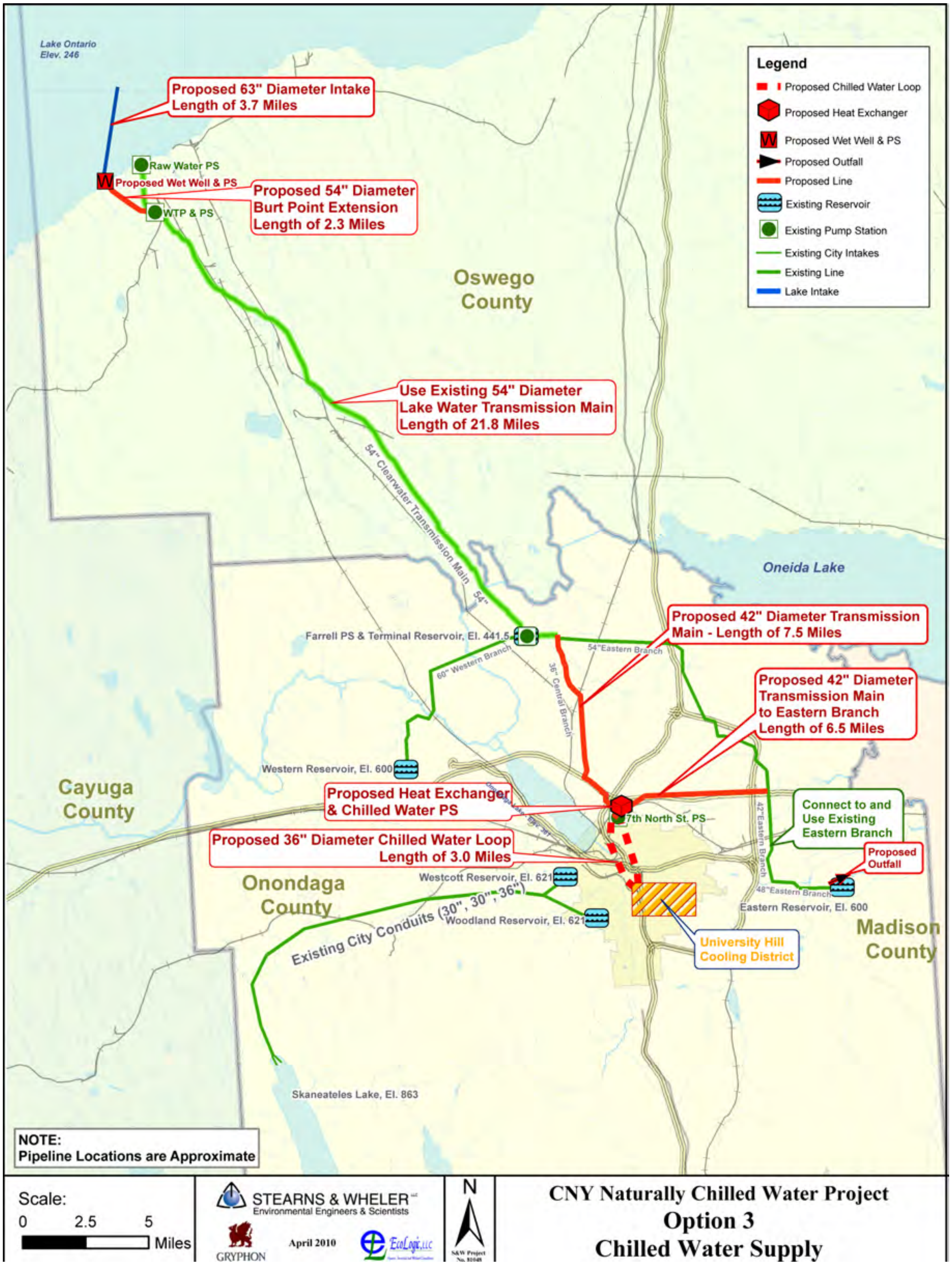


Figure 13-4. Schematic of Naturally Chilled Water - Option 4

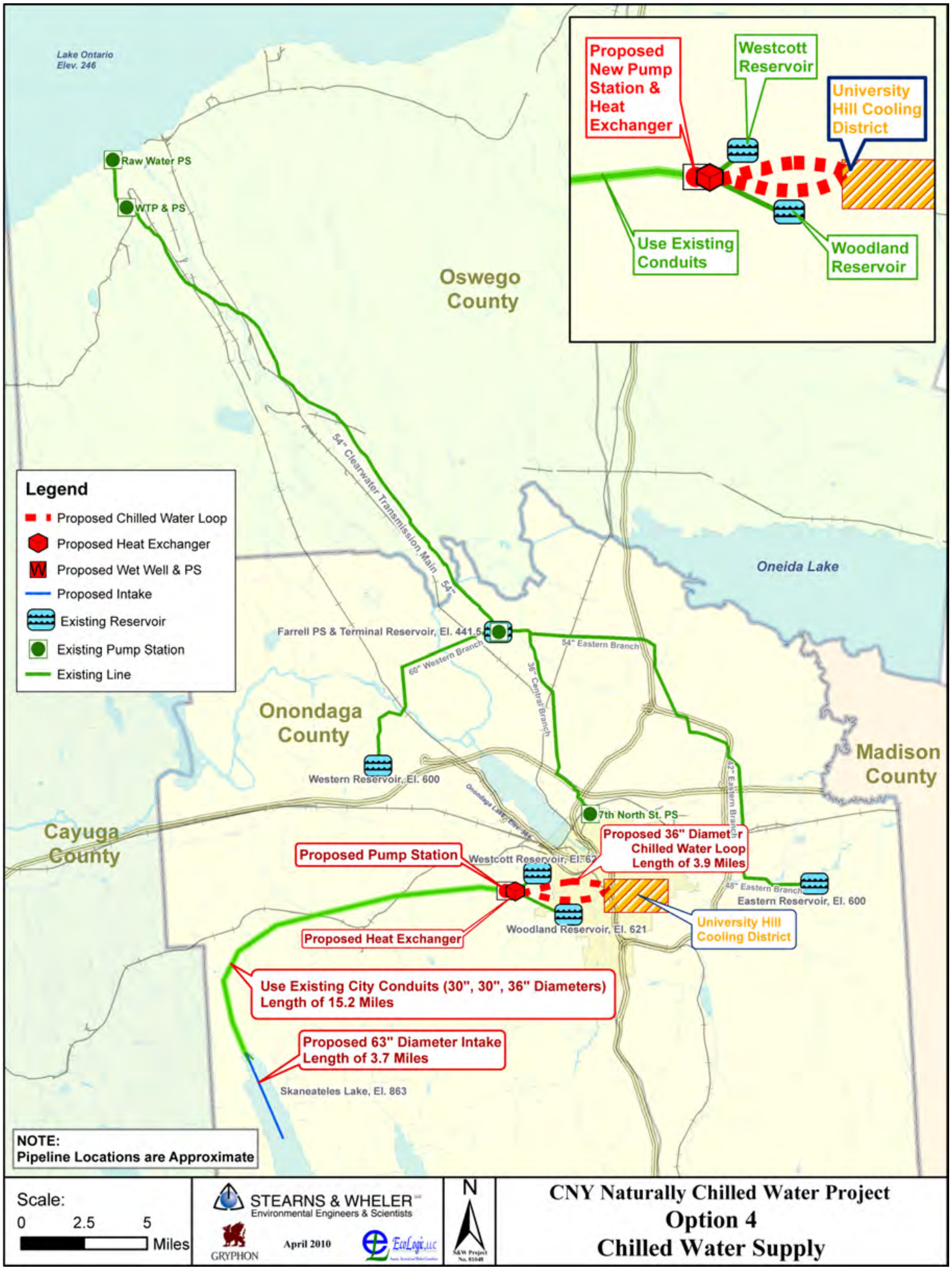
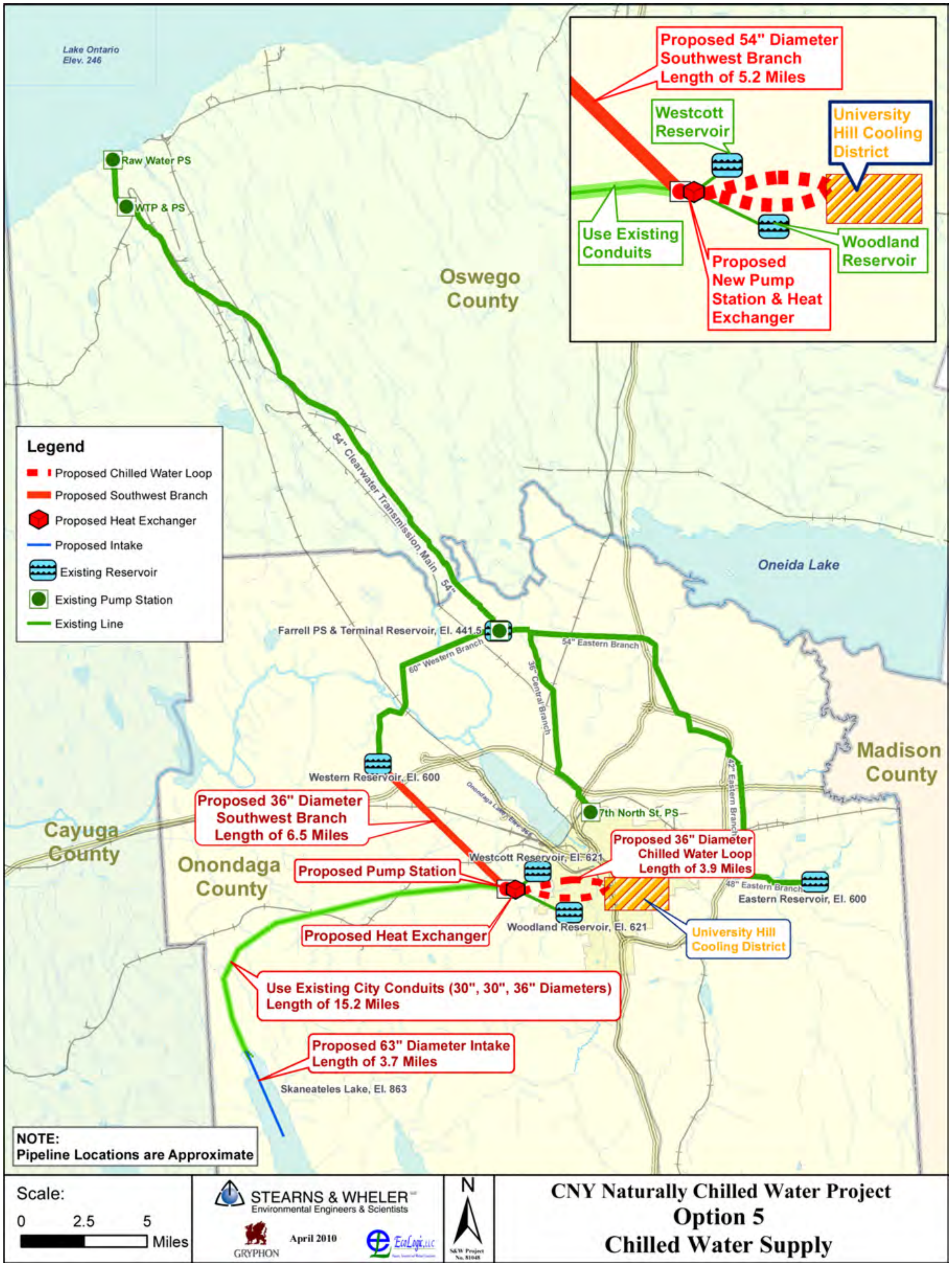


Figure 13-5. Schematic of Naturally Chilled Water - Option 5



13.7 Potential Chilled Water Users

Work described in earlier sections of this report identified existing individual buildings and industries with centralized comfort and process cooling loads which could potentially be chilled water customers. After consideration of the many buildings in the downtown Syracuse area, the central chilling plant for Syracuse University was selected as the best potential customer for a number of reasons, including:

- The chilled water plant has an existing single connection point.
- The SU campus has a significant steady need for chilled water.
- The chilled water plant has existing pumps, instrumentation, chemical addition systems, and other infrastructure.
- A central location that would allow for other potential customers to benefit from connection to the chilled water loop.

The SU chilled water plant provides comfort and process cooling to over 25 buildings totaling approximately 3.2 million square feet of building space. The peak cooling load developed by the SU Campus in recent years is approximately 5,000 tons[1], with this load occurring for several hours at a time during the warmest periods of the summer. The SU chilled water plant has the following characteristics (all values are approximate):

- Chilled water is supplied to buildings at 45 to 50ºF (7.2 to 10ºC).
- Water returning to the chilled water plant is at 58 to 60ºF (14.4 to 15.6ºC).
- Peak water flow is 6,000 gallons per minute (gpm) when load is 5,000 tons.
- Average water flow during summer is 2,000 gpm.
- The plant operates for six months per year and is shut down for the winter months.
- The plant delivers 5 to 6 million tons of cooling per season.
- Annual cost to operate the plant is $2.0 million (2008 dollars).
- Average cooling cost is $0.36 per delivered ton.

There are several hospitals adjacent to the SU Campus which could also be served by a new chilled water loop connected to the SU chilled water plant.

1. One ton of cooling is equivalent to the heat transfer of 12,000 British Thermal Units (BTU) per hour.

The existing chilled water plant is also a heating plant and supplies steam to both the SU Campus and the hospitals. The steam supply piping is in place to each hospital, but no existing piping could be used for chilled water supply and return. The possible addition of chilled water piping to serve the hospitals is considered later in this chapter.

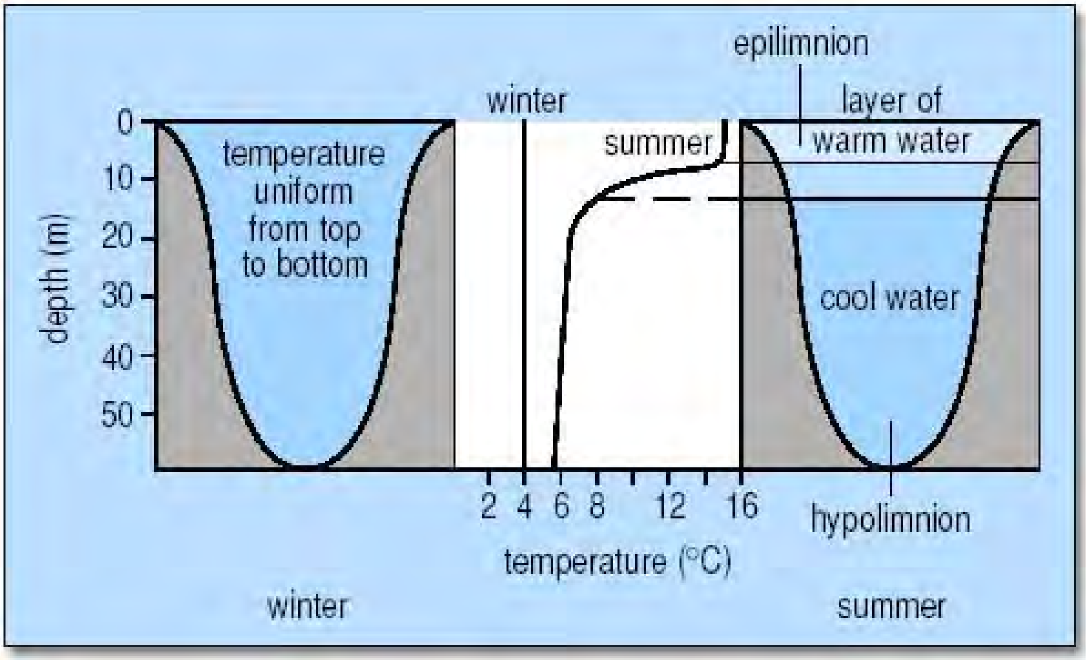
In order to develop cost estimates for a potential system, a design point was selected after considering the cooling load profile, withdrawal capacities from Lake Ontario and Skaneateles Lake, hydraulic capacity of the various existing pipelines, and existing potable water demands. Each of the options considered is based on withdrawing a maximum of 30 mgd from one of the lakes. The flow rate of 30 mgd converts to approximately 21,000 gpm for comparison to the peak SU chilled water flow rate of 6,000 gpm. After considering thermal losses during transmission from one of the lakes to the SU Campus, and additional losses through the heat exchangers, the proposed withdrawal rate of 30 mgd would supply approximately twice the cooling needed during the peak period, or about four times the average cooling load.

13.8 Intake Considerations

13.8.1 Intake Temperature

The five options under consideration rely on withdrawing water from either Lake Ontario or Skaneateles Lake. Existing potable water intake structures exist on each lake and are currently in use. The existing intakes withdraw water from relatively shallow depths of around 20 to 60 feet (6 to 18 m) and are therefore unsuitable for withdrawing consistently cold water and will require extension or replacement. Lake water temperatures vary by depth, with colder water available at increasing depths. Figure 13-6 shows seasonal temperature profiles typical for deep lakes in Central New York. During the winter months, each lake becomes uniform in temperature, at approximately 39°F (4ºC). Warmer weather during the spring and summer affects mostly the upper 45 feet (14 m) of the lake, as shown on the graphic.

Figure 13-6. Seasonal Temperature Profiles Applicable to Both Lake Ontario and Skaneateles Lake



Lake Ontario depths near Burt Point in Oswego are shown on Figure 13-7. Lake depth gradually increases with distance away from shore until a depth of approximately 200 feet (61 m), after which depth increases more quickly. The proposed intake is approximately 18,000 feet (5.5 km) in length and is shown at a depth of 250 feet (76 m). Water at this depth should be at approximately 39°F (4°C) year round.

Figure 13-8 is a graphic indicating the depths at the north end of Skaneateles Lake. The proposed intake shown reaches to a point 135 feet (41 m) deep, where summertime water temperatures can be expected to reach as high as 43°F (6°C). The intake shown is approximately 19,700 feet (6 km) long. Extending the intake to deeper water at 164 feet (50 m) would extend the length of the intake 13,100 feet (4 km) to a total length of 32,800 feet (10 km), and would allow 42°F (5.6°C) water to be obtained. This extension was deemed unnecessary, technically difficult, and expensive given the marginally cooler water available at the greater depth.

Figure 13-7. Bathymetry of Lake Ontario near Burt Point, Showing Proposed Intake Location and Depth

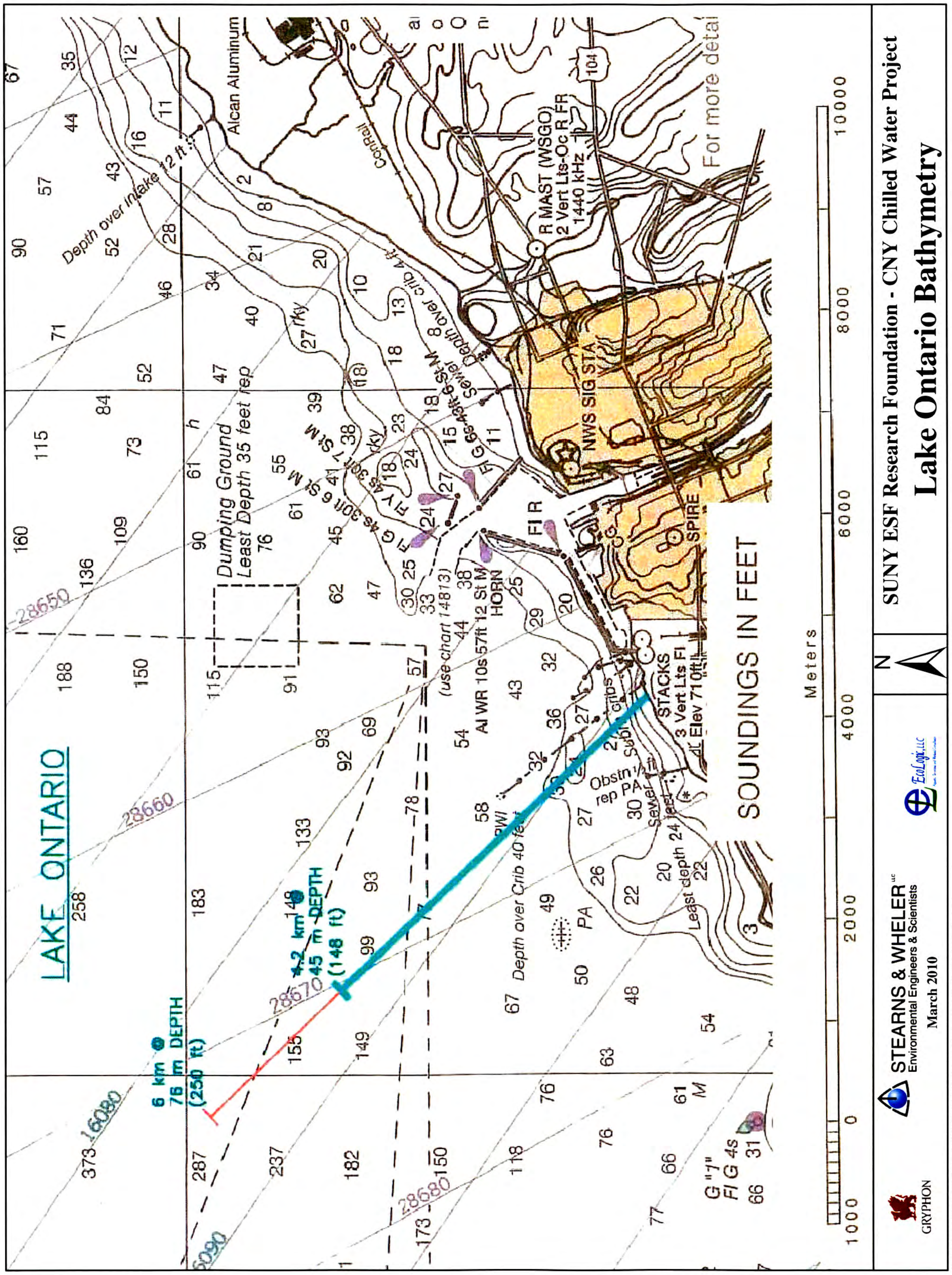
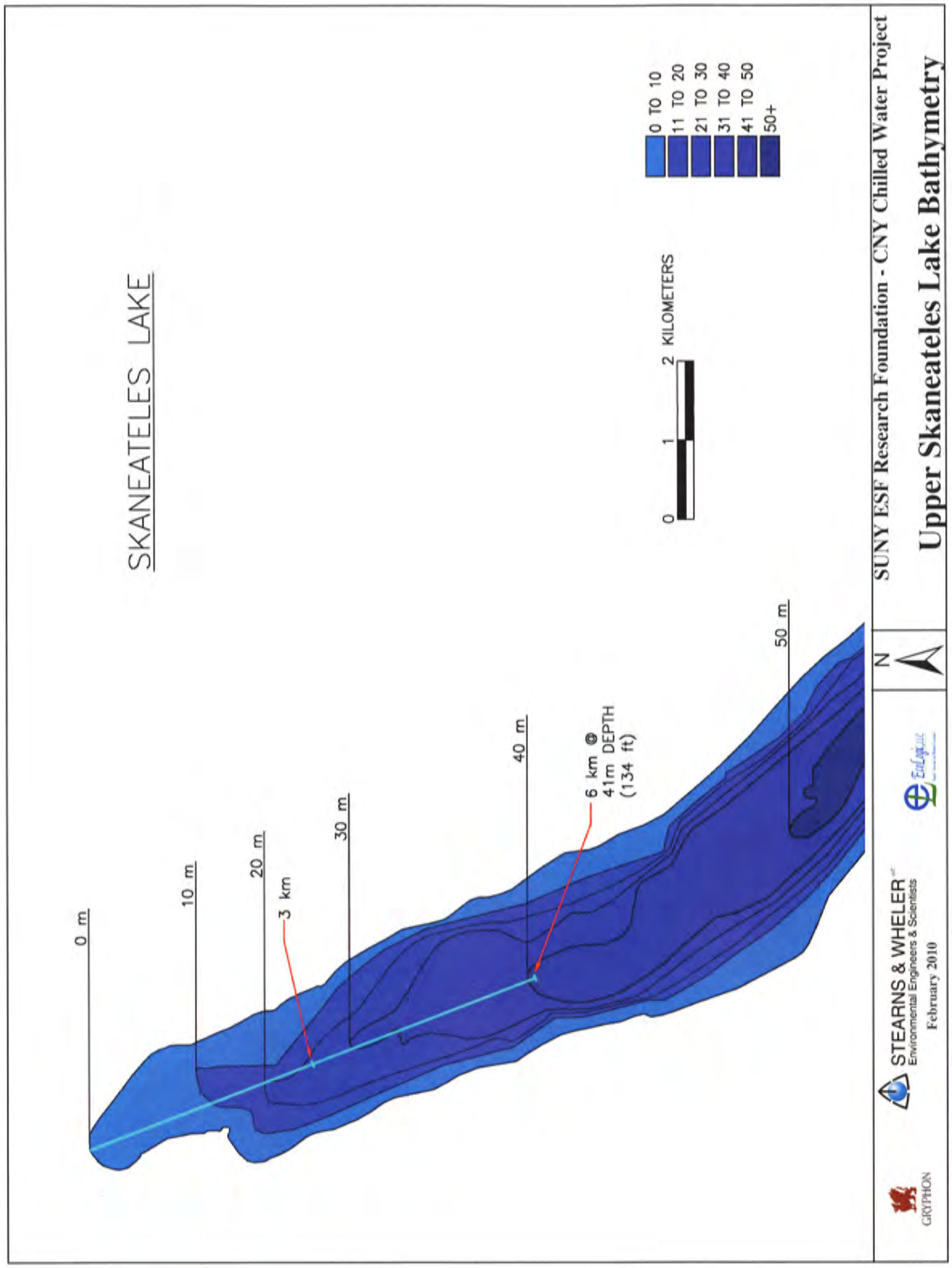


Figure 13-8. Bathymetry of Northern End of Skaneateles Lake Showing Proposed Intake Location and Depth



13.8.2 Intake Hydraulics

The diameter and material of the intake piping will determine the amount of flow possible. The material choices for the long intake pipe are limited to steel and high density polyethylene (HDPE) because of the need to float the pipe into position and then sink it to final position. The project team is considering an HDPE intake based largely on corrosion resistance, hydraulics and cost.

The limiting factor for an HDPE intake pipe is the pressure loading the pipe will experience during service. The design life for HDPE piping is selected based on the working pressure, with lower working pressures correlating to longer design life. At a working pressure of 13 feet of water column, the design life for an HDPE pipe is estimated at 75 years, based on published data from pipe suppliers. The project team selected the 75-year design life to appropriately represent the long time horizon of a public water supply project.

The hydraulic capacity of the intake pipe is a function of the working pressure, diameter, material of construction, and intake length. The largest commercially available HDPE piping is 63-inch outer diameter, with an inner diameter of approximately 57 inches. With a selection of 13 feet of water column as the working pressure, and assuming a 63-inch diameter intake pipe, the next factor considered was the length of the intake. Preliminary hydraulic calculations show that for a 20,000-foot (6 km) long intake (the approximate intake length proposed for all options in this study), the flow capacity is 33,000 gpm, or 47 mgd. When the intake length is extended to 33,000 feet (10 km) in length (which would be required to reach 42°F (4.6ºC) water in Skaneateles Lake), the flow capacity is reduced to 26,000 gpm, or 37 mgd.

13.8.2.a Lake Ontario Intake

An existing intake structure is located on the shore of Lake Ontario between the SUNY Oswego Campus and the NRG electrical generating station. The intake consists of a deep wet well shaft and an intake tunnel bored into the rock formations near the shore of Lake Ontario and serves the City of Oswego and the MWB. The existing intake wet well and tunnel draw lake water from a depth of approximately 58 feet (17.7 m) at a point approximately 6,000 feet (1.8 km) from the shoreline. The site of the existing City of Oswego/ MWB intake is not large enough to locate a new wet well and pump station. The Lake Ontario options consider a new intake structure located at Burt Point, approximately 1 mile west of the existing MWB and City of Oswego intakes. The MWB owns a development site on Burt Point appropriate for a wet well and pump station.

Water depths in Lake Ontario near Burt Point are shown in Figure 13-7, presented earlier in this section. Intake details are shown in Figure 13-9.

The following are critical assumptions regarding a new intake at Burt Point, Oswego:

- A new wet well will be required.
- New intake piping will be required.
- A new pumping station will be required.
- A new transmission pipeline approximately 2.3 miles (3.7 km) in length will be required to connect the new intake to the existing MWB transmission corridor rights-of-way.
- The existing intake will remain as a backup.
- The new intake piping will be sized to draw a maximum of 47 mgd.
- The new intake piping will consist of one 63-inch diameter pipe (outer diameter is 63 inches, inner diameter is 57 inches).
- The new intake piping would be buried near the shoreline to prevent damage from waves and erosion.

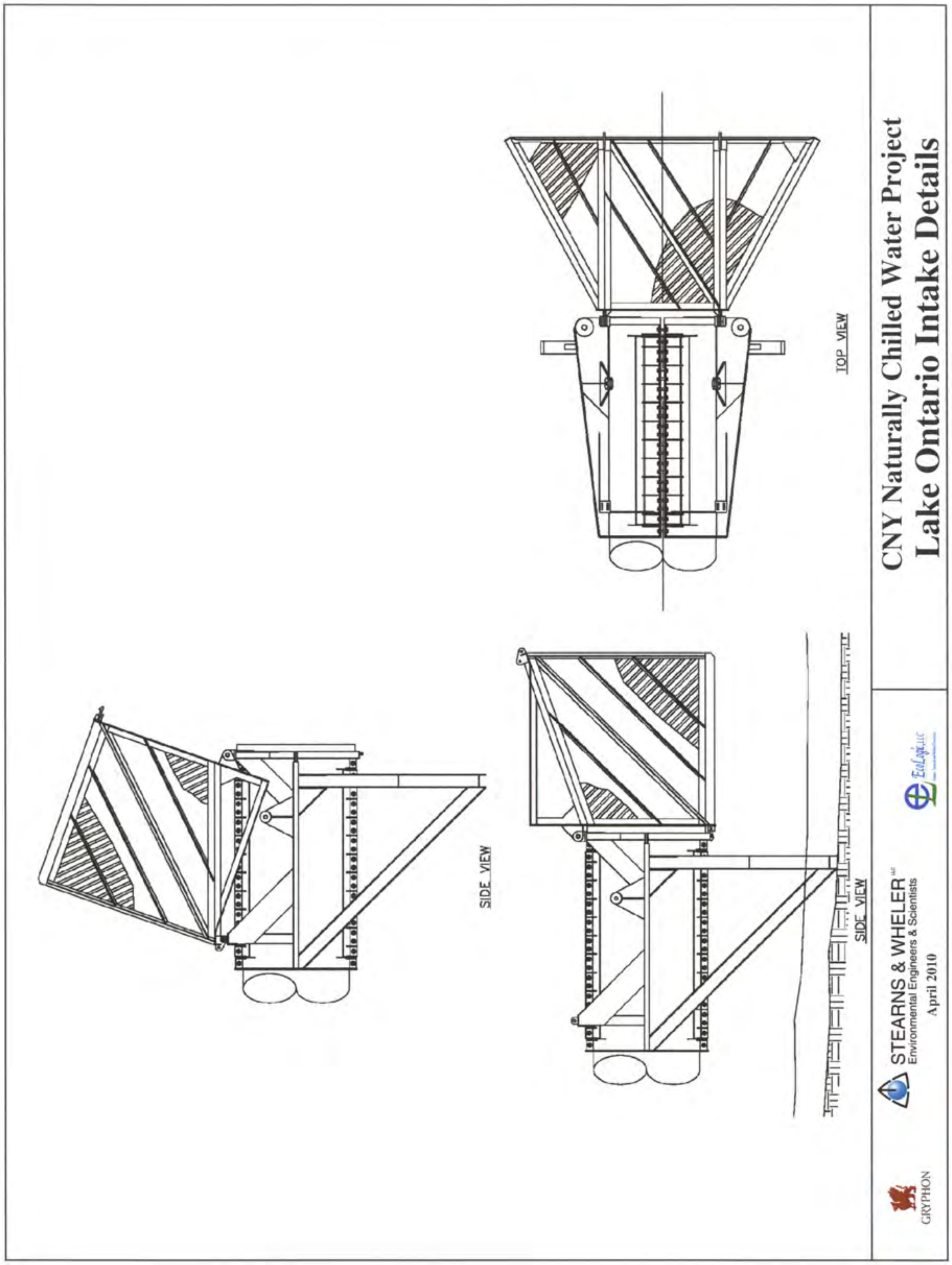


Figure 13-9. Intake Details - Lake Ontario

13.8.2.b Skaneateles Lake Intake

The existing intake structure consists of a shallow wet well located on the shore of Skaneateles Lake in the Village of Skaneateles. A pair of existing 54-inch diameter steel intake pipes extend into Skaneateles Lake and draw water from depths of 20 (6.1) and 40 feet (12.2 m)at distances of 4,000 (1.2) and 6,000 feet (1.8 km) from the shoreline. These existing intakes do not reach to the deeper water required to provide the colder water temperatures needed for a naturally chilled water project.

Skaneateles Lake has areas deep enough to provide the cold water required. Figure 13-8 shows Skaneateles Lake bathymetry. The deepest practical intake location is approximately 19,700 feet (6.0 km) from the northern shoreline with a depth of approximately 135 feet (41 m). Colder water is available in the deeper portion of the lake, but is much farther away from the north end of the lake where the existing conduit system flows by gravity to the City of Syracuse. Locating an intake near the midpoint of the lake would allow access to deeper and slightly colder water with a longer submerged pipe. For this reason, the project team recommends maintaining the existing wet well location and adding a new intake of approximately 19,700 feet (6.0 km). At a depth of 135 feet (41 m), the summertime intake water temperature will be approximately 43°F (6.1ºC). Lower temperatures can be expected for the rest of the year.

The following are critical assumptions regarding this intake:

- A new wet well will be required.
- New intake piping will be required.
- A new low lift pumping station will be required to lift the lake water from the new wet well into the adjacent existing wet well.
- The new intake piping will be sized to draw a maximum of 47 mgd.
- The existing intakes will remain as a backup and provide for flows in excess of 47 mgd.
- The new intake piping will consist of one 63-inch diameter (inside diameter 57 inches) pipe.
- The new intake piping would be buried near the shoreline to prevent damage from waves and erosion.

13.9 Section Summary

Five options for delivery of Naturally Chilled Water to Central New York are described. Options 1 - 3 use Lake Ontario as source water, while Options 4 and 5 utilize Skaneateles Lake. In Option 1, new infrastructure parallel to existing potable water pipelines is envisioned, while Options 2 - 5 all utilize existing potable water distribution infrastructure. Hydraulic considerations (Section 11.8.2) and intake locations (Figures 13-7 and 13-8) based on temperature considerations (Figure 13-6) together determine the flows of Naturally Chilled Water available for distribution.

14.0 Preliminary Evaluation: Options 1 - 5

14.1 Section Introduction

The five options rely on new and existing transmission line segments and pump stations (see Figures 11-1 through 11-5). For the purposes of assessing feasibility of the options, it is assumed that the shared use of existing MWB infrastructure could be negotiated; however, the MWB has its own obligations which may preclude the use of the existing infrastructure for a NCW project. The original project concept, described as Option 1, is to build a completely redundant system to transport lake water along the existing MWB transmission corridor. This original concept has the advantage of providing MWB with a back-up transmission pipeline to Central New York. Options 2 and 3 envision using MWB's existing infrastructure to reduce potential project costs and regulatory approval efforts, but provide less redundancy and could create water quality protection issues when using potable water for cooling purposes. A general understanding of the pumping requirements for Options 1 - 3 is needed before the specifics of each option are described later in this section.

14.2 Energy Considerations: Pumping Naturally Chilled Water

The energy required to move the water in a Naturally Chilled Water project must be compared to the amount of energy use offset by a reduction in mechanical chilling in order to understand the potential benefits of the project. The energy usage of existing mechanical chilling systems in the project area is well understood, and consists of the electrical energy to drive the mechanical chillers and water circulating pumps. In a Naturally Chilled Water project the main energy input will be electrical power to drive pumps to move water. The Lake Ontario options include both the energy to transport water from Oswego to Syracuse, and the energy needed to circulate water within a chilled water loop. The Skaneateles options have the advantage of allowing gravity flow from Skaneateles to Syracuse, but still requires energy addition to overcome friction losses in the intake pipeline and heat exchangers, and to circulate water within the chilled water loop. This section presents a general overview of the pumping energy required for each option.

The total pumping power required to move water between Lake Ontario and a new chilled water circulating loop is the sum of the elevation gain between Oswego and Syracuse and the friction loss of water traveling through the pipe between the two locations. In several of the options being considered, a new lake water transmission line from Lake Ontario would travel approximately 33 miles (53 km) between Oswego (elevation 246 feet (74.5 m) above sea level) and Seventh North Street in Syracuse (elevation 390 feet (119 m) above sea level). While the overall elevation gain along the proposed piping route is 144 feet (43.6 m), the route includes a high point at approximately 30 ft higher than the endpoint at Seventh North Street. The total elevation difference is therefore estimated at 174 feet (52.7 m).

The friction loss of water moving in a pipe is well understood and can be calculated from established equations. At a design flow of 30 mgd the expected friction loss in the piping between Oswego and Syracuse is approximately 210 feet (64 m). The total pumping energy required to move 30 mgd of water from Oswego to Syracuse is approximately 384 feet (116 m), 174 feet (52.7 m) of elevation plus 210 feet (64 m) of friction loss. Converted to horsepower, this equates to approximately 2,200 horsepower (HP), assuming a pumping efficiency of 90%. At an average electrical rate of $0.12 per kWh, 2,200 HP consumes electricity worth approximately $4,800 per day.

The surface of Skaneateles Lake is at an approximate elevation of 863 feet (266 m) above sea level. The existing potable water supply for the City of Syracuse flows by gravity from Skaneateles Lake to Syracuse, which is approximately 390 feet (120 m) above sea level. The Skaneateles Lake options considered in this report are based on gravity flow of the water to be used, and therefore do not include a pumping energy cost to move water from Skaneateles to Syracuse. A new wet well pumping system connecting the new deep water intake to the existing conduit system will be needed to raise the water withdrawn from Skaneateles Lake several feet to overcome the friction losses in the longer deep water intake. The daily electrical cost associated with this low lift pump station is estimated at $200 per day.

A chilled water loop from the Seventh North Street pump station to the Syracuse University chilled water plant would be approximately 7 miles (11 km) long and be constructed of 36 inch diameter steel piping in both directions. The estimated pumping requirements for the chilled water loop would be approximately 1,700 HP. The electrical energy required to operate the chilled water loop would be approximately $3,600 per day. The energy required to drive the chilled water loop would apply similarly to the Lake Ontario or Skaneateles Lake options, with slight differences in energy usage because of different lengths of the chilled water loop in different options.

In summary, any of the Lake Ontario options discussed would have energy costs of approximately $8,400 per day to operate, and the Skaneateles Lake options would have energy costs of approximately $3,800 per day. All energy cost discussed are based on an average total electrical cost of $0.12 per kWh, which reflects the electrical market in Central New York as of 2009.

14.3 Option 1 - New Parallel Pipeline from Oswego to the City of Syracuse

In this option, an entirely new chilled water delivery system would be constructed adjacent to the existing MWB clearwater transmission line and within the same rights-of-way. Figure 11-1 shows the proposed locations of the new transmission lines and major structures associated with this option. This option uses the following assumptions:

- New intake on Burt Point to provide a maximum flow of 30 mgd.
- New influent pumping station to provide the energy needed to move the water from the intake wet well to the heat exchange facility.
- New 42-inch diameter transmission pipeline from Oswego to Seventh North Street in Syracuse.
- New heat exchange and pumping facility located near the Seventh North Street pump station.
- New chilled water loop from the Seventh North Street site to Syracuse University chilled water plant, 36-inch diameter.
- New 54-inch diameter outfall to Onondaga Lake.
- Water would not be used for potable water supply before or after thermal harvesting.
- The new pipeline could serve as a backup water transmission main for MWB in the event of an emergency, but would require a boil water notice to consumers to be utilized in this fashion.

14.3.1 Option 1: New Chilled Water Customer Flexibility

The new transmission system would be pressurized for the entire distance. The potential for new cooling customers in close proximity to the transmission main in the future could be easily accommodated in the design by adding connections along the transmission route. If new chilled water customers are identified in the future, new transmission lines to their facilities can be extended from the nearest point of connection. Potential new cooling customers in the Oswego or Fulton areas would also need to be evaluated to determine if once-through cooling would be possible or if a heat exchange facility would be required.

14.3.2 Option 1: Potable Water Use Flexibility

This option does not include treatment of the raw water to potable standards, but does offer the benefit of bringing a large amount of potential drinking water (if treated) to the communities along the transmission route. If potable water needs should arise in any of these communities in the future, the transmission pipeline would be an excellent source for high quality water which could be treated to potable grade after withdrawal from the pipeline.

14.3.3 Option 1: Cross-Connection Controls

No cross-connection controls would be required for this option since it does not involve potable water, except if interconnections are proposed for redundancy. If the transmission main were to be utilized as an emergency backup to the MWB clearwater transmission main, it would have to be physically disconnected when not used for that purpose to meet New York State Department of Health requirements.

14.3.4 Option 1: Return Water Collection System

The raw water would flow through the heat exchange facility and then through piped segments to the outfall. Disinfection of the lake water would be required prior to discharge to Onondaga Lake because of concerns regarding transfer of both native and invasive aquatic organisms from Lake Ontario to Onondaga Lake.

14.3.5 Option 1: Potable Water System Connection

While no connection to the potable water system is an active part of this potential option, the redundancy of the intake, primary pump station, and primary transmission line provides a significant benefit. The MWB main transmission line is a single conduit, and having a completely redundant conduit in close proximity would have obvious advantages.

14.3.6 Option 1: Outfall Location

The outfall for this option would be Onondaga Lake. The proposed 54 inch diameter outfall piping would discharge at a point and depth in the lake determined to be of the most benefit or the least detriment to the lake. Known factors involved in the determination of the outfall location include: (1) depth, which could vary by time of year; (2) the need for diffusers; and (3) diffused oxygen content of the cool water.

14.3.7 Option 1: Hydraulic Considerations

The proposed new intake would have a hydraulic capacity of 47.0 mgd. The pumping stations and heat exchange facility would initially be sized for 30 mgd, expandable to 47.0 mgd with the addition of pumps and heat exchangers. The main transmission line would be sized for 30 mgd, and be a 42-inch diameter line. The chilled water loop and associated pumping system are sized for 30 mgd and are 36-inch diameter steel piping for cost estimating and alternative comparison purposes. Expansion of the chilled water loop to allow flows over 30 mgd in the future would require the installation of a second chilled water pipeline, or replacement of the original chilled water line with a larger diameter piping system.

14.3.8 Option 1: Option Viability

Initial investigation of this option indicates that it has a very high initial capital cost. However, the option also has the distinct benefit of providing a redundant source of high quality water to the Cities of Oswego, Fulton, and Syracuse.

14.4 Option 2 - Lake Ontario Intake, Shared Use of Existing Pipeline, Locate Heat Exchanger Near Terminal Reservoir

This option shares use of existing infrastructure where available and adds new components where needed. A new heat exchange facility to be located near Terminal Reservoir would be a key component of this option. A new chilled water loop from the heat exchange facility to the Syracuse University chilled water plant would need to be constructed. Figure 11-2 shows the proposed locations of the major structures associated with this option. This option is based on the following assumptions:

- New intake at Burt Point to provide a maximum flow of 47 mgd.
- New transmission line segment from Burt Point to the existing MWB water treatment plant in Oswego.
- New influent pumping station to provide the energy needed to move the water from the intake wet well to the existing MWB water treatment plant in Oswego.
- Raw water treated to potable standards at the existing MWB treatment plant in Oswego.
- Shared use of the existing 54-inch diameter clearwater transmission pipeline from the water treatment plant to the new heat exchange facility near Terminal Reservoir.
- New heat exchange facility near Terminal Reservoir initially sized for 30 mgd.
- New closed chilled water loop between the heat exchange facility and the Syracuse University chilled water plant, 36-inch diameter.
- New chilled water pumping station initially sized for 30 mgd, located at the heat exchange facility.
- Economic benefits from the water would be increased, since it would be sold once for cooling and once for potable use.
- Potable water transferred to Terminal Reservoir after thermal harvesting.
- New outfall to Oneida River for any periods when cooling water demand exceeds potable water demand.

14.4.1 Option 2: New Chilled Water Customer Flexibility

The clearwater transmission line would remain a potable, pressurized system. The new chilled water loop between Terminal Reservoir and the Syracuse University chilled water plant would offer potential new clients a cooling resource to tap into. This pressurized piping loop could be tapped in the future if new chilled water customers are identified along the route. Proximity to the piping route would be the critical factor in making connection feasible for new customers.

14.4.2 Option 2: Potable Water Use Flexibility

This option does not increase or decrease the amount of potable water available for use during most conditions. During some peak cooling periods, more lake water may be withdrawn, treated and thermally harvested than is needed for potable consumption in the existing service areas. During these periods, the excess potable water would be discharged to an outfall on a tributary to the Oneida River.

14.4.3 Option 2: Cross-Connection Controls

The multiple barrier approach described later in this chapter would be utilized with this option. The cross-connection controls would be located at the heat exchange facility near Terminal Reservoir.

14.4.4 Option 2: Return Water Collection System

The return water from the heat exchange facility would be transferred through pipe segments to the Terminal Reservoir.

14.4.5 Option 2: Potable Water System Connection

The potable water system connection for this option would occur at the heat exchange facility at Terminal Reservoir. After thermal harvesting, the potable water would be returned to the MWB distribution system at Terminal Reservoir.

14.4.6 Option 2: Outfall Location

Historical data from 2003 to 2008 indicate that the average potable water flow through the clearwater transmission main is 22 mgd, with slightly higher flows occurring in warmer months and slightly lower flows occurring in colder months. Using an assumed peak flow rate of 30 mgd for the chilled water system indicates that there will be periods of excess potable water after thermal harvesting at the heat exchange facility. These periods of peak cooling demand will likely coincide with periods of higher potable water demand.

When the cooling demand is larger than the drinking water demand, the excess potable water will flow into the existing distribution pipeline near Terminal Reservoir and continue to fill the reservoir until it is at full capacity, with transfer to the MWB Eastern and Western Reservoirs also available. The existing transmission pipeline system will allow the potable water from Terminal Reservoir to fill the Eastern and Western Reservoirs to capacity. Once the reservoirs are full, the excess potable water (if any) will be piped to a new outfall located on Mud Creek, a small creek near the site which is tributary to the Oneida River.

The amount of water sent to the outfall will be on the order of 5 to 10 mgd. Study of the outfall location and environmental factors affecting it would need to be conducted to determine if Mud Creek and the Oneida River have the capacity to allow the projected flows.

Figure 14-1. Image of Terminal Reservoir of the Metropolitan Water Board (see Figure 11-2). A Heat Exchange Facility would be located near the reservoir and the reservoir would be filled if cooling water demands exceeded drinking water demands

14.4.7 Option 2: Hydraulic Considerations

The existing MWB transmission system from Oswego to the proposed heat exchange facility near Terminal Reservoir has a capacity of 62.5 mgd, well in excess of the 30 mgd target flow rate. The existing raw water pumping station in Oswego has a current capacity of over 30 mgd, with room for additional pumps to increase the capacity. The existing MWB treatment plant is not sized to treat as much as 62.5 mgd, and has a capacity which varies with influent water quality and temperature. More detailed study would be needed to determine the expected treatment capacity of the existing MWB water treatment plant if it were receiving influent lake water from a deep intake location with the associated colder temperatures and lower turbidity levels currently being treated.

14.4.8 Option 2: Option Viability

Initial investigation of this option indicates that it has the benefit of lower installed cost than some other options because of the shared use of existing MWB infrastructure.

14.5 Option 3 - Lake Ontario Intake, Shared Use of Existing Pipeline, Heat Exchanger Near Seventh North Street

This option shares use of existing infrastructure where available and reduces the length of the chilled water loop. A new closed chilled water loop from the heat exchange facility to the Syracuse University chilled water plant would need to be constructed. Figure 11-3 shows the proposed locations of the new transmission lines and major structures associated with this option. This option is based on following assumptions:

- New intake structure at Burt Point to provide a maximum flow of 30 mgd.
- New transmission line segment from Burt Point to the existing MWB water treatment plant in Oswego.
- New lake water pumping station to provide the energy needed to move the water from the intake wet well to the existing MWB water treatment plant in Oswego.
- Raw water treated to potable at the existing MWB water treatment plant in Oswego.
- Utilize the existing 54-inch diameter clearwater transmission pipeline from the water treatment plant to Terminal Reservoir.
- New bypass piping segment, 42-inch diameter, from just before Terminal Reservoir to the Seventh North Street pump station.
- New heat exchange facility near the Seventh North Street pump station initially sized for 30 mgd.
- New closed chilled water loop between the heat exchange facility and the Syracuse University chilled water plant, 36-inch diameter.
- New chilled water pumping station initially sized for 30 mgd, located at the heat exchange facility.
- Economic benefits from the water would be increased, since it would be sold once for cooling and once for potable use.

- Potable water transferred by a new pump station to the Eastern Branch of the existing MWB transmission system after thermal harvesting by pumping along a new transmission segment along the New York State Thruway corridor.
- New outfall to Onondaga Lake.

14.5.1 Option 3: New Chilled Water Customer Flexibility

The new chilled water loop between Seventh North Street and the Syracuse University chilled water plant would offer potential new clients a location to tap into until the 30 mgd capacity is fully utilized. This pressurized piping loop could be tapped in the future if new chilled water customers are identified along the route. Proximity to the piping route would be the critical factor in making connection feasible for new customers.

14.5.2 Option 3: Potable Water Use Flexibility

This option does not increase or decrease the amount of potable water available for use during most conditions. During some periods, more potable water may be withdrawn, treated and thermally harvested than is needed for potable consumption in the existing service areas. During these periods, the excess potable water would be discharged to the outfall.

14.5.3 Option 3: Cross-Connection Controls

The multiple barrier approach described later in this chapter would be utilized with this option. The cross-connection controls would be located at the heat exchange facility.

14.5.4 Option 3: Return Water Collection System

The excess water from the heat exchange facility would be transferred through piped segments to Onondaga Lake for discharge.

14.5.5 Option 3: Potable Water System Connection

The potable water system connection for this option would occur at the Eastern Branch transmission line where it crosses the New York State Thruway. A new pumping station would be required to return the thermally harvested water to the MWB Eastern Branch due to elevation. The hydraulics of returning the thermally harvested water to the Eastern Branch are complicated, and more study would be needed to determine if this option is viable.

14.5.6 Option 3: Outfall Locations

The outfall for this option would be Onondaga Lake. The same comments concerning the outfall listed for Option 1 would apply to this option.

14.5.7 Option 3: Hydraulic Considerations

The existing MWB transmission system from Oswego to the proposed heat exchange facility near Terminal Reservoir has a maximum hydraulic capacity of 62.5 mgd, well in excess of the 30 mgd target flow rate. The existing central transmission pipeline from Terminal Reservoir to the Seventh North Street pump station has a diameter of 36 inches, with a hydraulic capacity well below 62.5 mgd, and would be replaced with a new 42-inch diameter transmission line. The existing MWB raw water pumping station in Oswego has a current capacity of over 30 mgd, with room for additional pumps to increase the capacity. The existing MWB treatment plant is not sized to treat as much as 62.5 mgd, and has a capacity which varies with influent water quality and temperature. More detailed study would be needed to determine the expected treatment capacity of the existing MWB water treatment plant if it were receiving influent lake water from a deep intake location with associated colder temperatures and lower turbidity levels.

14.5.8 Option 3: Option Viability

Initial investigation of this option indicates that it has a high initial capital cost and an additional re-pumping cost to return water to the MWB Eastern and Western Branch reservoirs. Compared to the other options being considered, this option does not appear to have any distinct advantages.

14.6 Option 4 - Skaneateles Lake Intake, Use Existing Pipeline, Locate Heat Exchanger Near City

This option makes use of existing infrastructure where available and adds new components where needed. A new closed chilled water loop from the heat exchange facility to the Syracuse University chilled water plant would need to be constructed. Figure 11-4 shows the proposed locations of the new transmission lines and major structures associated with this option. This option is based on the following assumptions:

- New intake structure to provide a maximum flow of 47 mgd.
- New low lift lake water pumping station to provide the energy needed to move the water from a new intake wet well to the existing wet well where existing conduits lead to the city.
- Utilize the existing conduits to transport lake water by gravity flow to the new heat exchange facility near the Andrews Gate House.
- Lake water treated to potable standards by chemical addition at the existing city treatment facilities.
- Periodic turbidity problems in Skaneateles Lake water supply would be minimized or eliminated by use of the deep water intake.
- New heat exchange facility near the city initially sized for 30 mgd.
- New closed chilled water loop between the heat exchange facility and the Syracuse University chilled water plant (approximately 3 miles (5 km) each way), 36-inch diameter.
- New chilled water pumping station sized for 30 mgd, located at the heat exchange facility.
- Potable water transferred to city reservoirs and/or standpipes via a new pump station after thermal harvesting (maintaining city high/low flow gradients).
- Economic benefits from the water would be increased, since it would be sold once for cooling and once for potable use.
- New outfall to Onondaga Creek, which flows to Onondaga Lake. Environmental and hydraulic study of the Onondaga Creek section affected by the potential outfall would need to be undertaken if this option is considered further.
- City potable water demands in excess of 47 mgd would be supplied by use of the new and existing intakes in Skaneateles Lake.

14.6.1 Option 4: New Chilled Water Customer Flexibility

The clearwater transmission line would remain a potable, pressurized system. The new chilled water loop between the heat exchange location (see Figure 11-4) and the Syracuse University chilled water plant would offer potential new clients a cooling resource to utilize. This pressurized piping loop could be tapped in the future if new chilled water customers are identified along the route. Proximity to the piping route would be the critical factor in making connection feasible for new customers.

14.6.2 Option 4: Potable Water Use Flexibility

This option does not increase or decrease the amount of potable water available for use during most conditions. Historical data show that more than 30 mgd of water is withdrawn from Skaneateles Lake for most of the year, so there should be a good match between cooling need and potable need, resulting in very little or no discharge to the outfall. During any period where potable demand is less than cooling water demand, the excess potable water would be used to fill any available reservoir or standpipe capacity and then be discharged to the outfall as a last resort.

14.6.3 Option 4: Cross-Connection Controls

The multiple barrier approach described later in this chapter would be utilized with this option. The cross-connection controls would be located at the heat exchange facility near Andrews Gatehouse.

14.6.4 Option 4: Return Water Collection System.

The return water from the heat exchange facility would be returned to the existing conduits via a new pump station for distribution to the reservoirs and standpipes.

14.6.5 Option 4: Potable Water System Connection

The potable water system connection for this option would occur at the heat exchange facility near Andrews Gatehouse.

14.6.6 Option 4: Outfall Locations

The outfall for this option would be a constructed outfall on Onondaga Creek, leading to Onondaga Lake. Environmental and hydraulic study of the Onondaga Creek section affected by the potential outfall, and of Onondaga Lake, would need to be undertaken if this option is considered further.

14.6.7 Option 4: Hydraulic Considerations

Option 4 consists of new intakes and a new low lift pump station to withdraw raw water from Skaneateles Lake and transfer it to the existing wet well. The existing wet well does not have the necessary hydraulics to allow gravity flow from the deep water intake to the existing conduit transmission system. A low lift pump station would add several feet of energy head to the raw water and transfer it to the existing wet well.

After chlorination and fluoridation, the potable water would move into the three existing conduits and travel approximately 18 miles (29 km) by gravity until it reaches the Andrews Gatehouse. A heat exchanger and pump station at this point would provide for thermal harvesting. The potable water would flow to either Woodland or Westcott Reservoir after thermal harvesting.

14.6.8 Option 4: Option Viability

Initial investigation of this option indicates that it has some distinct advantages, such as use of existing city infrastructure and dual use of the water for potable and cooling. This option will continue to be considered in future tasks.

14.7 Option 5 - Skaneateles Lake; Shared Use of Existing City Transmission Conduits, Connection to Lake Ontario

Option 5 combines attractive portions of two previously considered options. Option 5 proposes to use the existing infrastructure of both Skaneateles Lake and Lake Ontario to provide the chilled water benefit proposed by Option 4, while increasing the redundancy of the City of Syracuse water by adding new components to the MWB system. Option 5 (shown in Figure 11-5) has the following characteristics:

- A new deep water intake at Skaneateles Lake sized to withdraw up to 47 mgd from deep water.
- A new low lift pump station and wet well in Skaneateles to transfer lake water to the existing conduits.
- A new heat exchange facility near Syracuse.
- A new main transmission line connecting the MWB Western Branch pipeline to the city distribution system near the city reservoirs. This main transmission line is called the Southwest Branch and has been considered in previous studies to provide redundancy to the city water system.
- Skaneateles Lake water flow to Syracuse would be set to a steady 30 mgd.

- Economic benefits from the water would be increased, since it would be sold once for cooling and once for potable use.
- MWB supply to the city potable water supply would increase by 5 to 20 mgd, flowing through the existing distribution network.

Option 5 appears to provide more benefits than any other option considered, including:

- Reduction in the average amount of water withdrawn from Skaneateles Lake, which will be seen as a benefit to the Skaneateles community.
- All water used for cooling would be consumed as potable, since city potable use is almost always above 30 mgd.
- The Southwest Branch pipeline would provide redundancy to the city water system, and redundancy to the MWB as the MWB could be partially served by the City supply.
- Periodic turbidity problems in the Skaneateles Lake water supply would be minimized or eliminated by use of the deep water intake.
- The MWB would retain complete control of its system, with the opportunity of additional potable water sales to the city.

14.8 Potable Water Supply Protection

The protection of the potable water supply is one of the most important considerations in this study. Option 1 is the only option considered which does not share potable water infrastructure to supply the naturally chilled water to customers. All the other options rely on the economy of sharing potable water infrastructure of the Metropolitan Water Board (MWB) or the City of Syracuse.

The New York State Department of Health (NYSDOH) regulates potable water systems within the state. Section 8.10.2 of Recommended Standards for Waterworks specifically prohibits the return of cooling water in heat exchange devices back to the potable water system. Options 2, 3, and 4 each rely on a heat exchanger to transfer thermal energy from potable water to a separate cooling water loop, making them out of compliance with this recommended waterworks standard. Preliminary discussions with NYSDOH indicate that the agency was willing to consider the possibility of allowing water which has passed through a heat exchanger to be returned to the potable water system if the water is protected by multiple barriers.

This approach is similar to that which is currently and successfully in use at the Toronto Deep Lake Water Cooling Project, which includes the following multiple barrier safeguards:

- Pressure sensors which constantly monitor water pressure in the potable water side and the cooling water side of the heat exchanger. The concept is that the potable water side would always be maintained at a higher pressure than the cooling water side, and any potential leak through a heat exchanger plate or gasket would result in potable water entering the cooling loop, but would not allow non-potable water to be introduced to the potable water supply. The controller would be set to monitor the pressures constantly, with a required pressure differential to be maintained between the two sides of the heat exchanger. Should the pressure differential be compromised for any reason, the automated system controller would close the automated valves to bypass potable water flow around the heat exchanger until the problem is investigated and resolved.
- A tracer chemical would be introduced into the chilled water loop and maintained at a specified concentration. Detectors for this tracer chemical on the potable water side of the heat exchanger would constantly monitor for the tracer, and the controller would automatically divert potable water flow around the heat exchanger if the tracer chemical was detected.
- Only food grade chemicals would be used for routine maintenance in the chilled water loop.

This multi-barrier cross-connection control concept was presented to the NYSDOH in writing. At the time of this report preparation, we have only received verbal feedback from NYSDOH. Mike Montysko, Chief of the Design Section for NYSDOH, has indicated that the multi-barrier approach proposed would be acceptable only if double-wall heat exchangers are utilized.

Mechanical heat exchangers are available in two main types: plate-and-frame and shell-and-tube. Shell-and-tube heat exchangers consist of a number of smaller diameter tubes or pipes contained within a larger diameter pipe or “shell.” The shell has a pipe flange at each end and the tubes run through the pipe flange and are either welded in place, expanded into place, or sealed with chemical sealants. The large amount of welding and limited number of tubes which can be fit into any shell make this application more expensive per unit of heat transfer. Shell-and-tube heat exchangers are more appropriate for lower flow applications. One primary manufacturer of this equipment cites appropriate flow rates of 30 to 4,700 gpm (0.5 to 7 mgd) for the equipment. A group of shell-and-tube heat exchangers in parallel could offer the required thermal transfer and redundancy required for the project, but at a much higher cost than for plate and frame heat exchangers.

Plate-and-frame heat exchangers consist of a large number of thin corrugated metal plates with small interstitial spaces for fluid flow. The corrugations between plates allow fluids to flow along the face of each plate with thermal transfer through the thin metal barrier. Elastic gaskets separate one plate from another and form the barrier from mixing the two heat exchange fluids. Groups of the thin metal plates are fastened to a large "frame" which compresses the gaskets together to establish the barrier between plates. There is no welding involved, and these systems are expandable from approximately 20 to 200 metal plates per frame. The expandability and lower production cost of these heat exchangers makes them the only practical choice for the large flow anticipated by this project. Double-walled plate-and-frame heat exchangers are commercially available for small flow rate projects where it is essential not to mix the two heat exchange fluids. Therefore, custom-made double-wall exchangers would be necessary for the flows proposed for this project. Double-walled plate-and-frame heat exchangers also have a lower thermal transfer efficiency rate; therefore, significantly more plate area is required to achieve the same level of thermal efficiency as a single wall exchanger. One primary manufacturer of plate-and-frame heat exchangers offers single-walled units with flow capacities of up to 23 mgd in a single unit. Several smaller units in parallel could provide the required cooling capacity with appropriate redundancy.

Single-wall plate-and-frame units offer considerable advantages for large-scale projects and will be used as the basis for the opinion of costs in this chapter.

Preliminary indications are that the NYSDOH will not permit return of water from a heat exchanger to the potable water system without a double-wall heat exchanger. Demonstration of the redundant multiple barrier system discussed previously may allow the NYSDOH to endorse the project in the future, but that is not certain. It is quite possible that the NYSDOH will decide that even with a multiple barrier approach, the risk to the potable water supply is too great and the project cannot move forward. Opposition to this project concept by NYSDOH would have the greatest impact on the feasibility of Options 2, 3, 4, and 5.

14.9 Section Summary

The five Options identified in Section 11 are further described and a preliminary evaluation was performed for each Option. Evaluation criteria included flexibility with respect to adding new customers, potable water use considerations, return water collection, outfall location and hydraulic considerations as appropriate for each Option.

15.0 Opinions of Construction Costs: Options 1 - 5

15.1 Section Introduction

The preliminary cost estimates prepared for Options 1 - 5 are presented in Tables 15-1 through 15-6. The preliminary cost estimates are based on experience with the Toronto and Cornell chilled water projects, actual 2009 bid results from a large force main project in central New York, published estimating guides, and professional judgement. All values are in 2009 dollars.

15.2 Opinion of Costs: Option 1

Option 1: Original Concept - Lake Ontario intake with new transmission pipeline (Figure 11-1).

Table 15-1 shows the opinions of project costs for Option 1. Later tables show more detail, and derivation of costs.

Table 15-1. Option 1: Opinion of Project Costs

Item	Estimated Quantity	Unit Price	Opinion of Cost
New intake structure and wet well	1	$38,000,000	$38,000,000
New raw water pump station	1	$6,700,000	$6,700,000
New transmission line, 54-inch pipe (LF)	12,000	$480	$5,800,000
New transmission line, 42-inch pipe (LF)	156,000	$430	$67,000,000
New 30 mgd heat exchange/pumping facility	1	$7,000,000	$7,000,000
Chilled water buried piping, 36-inch pipe (LF)	16,000	$1,100	$18,000,000
Piping river crossings	6	$500,000	$3,000,000
Piping stream crossings	8	$150,000	$1,200,000
Piping state highway or railroad crossings	22	$300,000	$6,600,000
Piping wetlands crossings	8	$20,000	$160,000
Piping road way crossings, rural	22	$100,000	$2,200,000
Piping road way crossings, urban	5	$130,000	$650,000
Outfall cost	1	$3,400,000	$3,400,000
Subtotal			**$160,000,000**
Construction Contingency			$40,000,000

Table 15-1. Option 1: Opinion of Project Costs (Continued)

Item	Estimated Quantity	Unit Price	Opinion of Cost
Construction Total			**$200,000,000**
Engineering, Legal, Fiscal			$50,000,000
Total Project Cost			**$250,000,000**
Notes: LF = Linear Feet All cost estimates are in 2009 dollars. See Tables 15-6 through 15-11 for derivation of costs.			

15.3 Opinion of Costs: Option 2

Option 2: Lake Ontario intake utilizing existing pipeline segments; heat exchange facility near Terminal Reservoir (Figure 11-2).

Table 15-2. Option 2: Opinion of Project Costs

Item	Estimated Quantity	Unit Price	Opinion of Cost
New intake structure and wet well	1	$38,000,000	$38,000,000
New raw water pump station	1	$3,400,000	$3,400,000
New transmission line, 54-inch pipe (LF)	12,000	$480	$5,800,000
New 30 mgd heat exchange/pumping facility	1	$7,000,000	$7,000,000
Chilled water buried piping, 36-inch pipe (Linear Feet)	58,000	$1,100	$64,000,000
Piping river crossings	0	$500,000	$0
Piping stream crossings	2	$150,000	$300,000
Piping state highway or railroad crossings	4	$300,000	$1,200,000
Piping wetlands crossings	2	$20,000	$40,000
Piping road way crossings, rural	3	$100,000	$300,000
Piping road way crossings, urban	5	$130,000	$650,000
Outfall cost	1	$1,000,000	$1,000,000
Subtotal			**$122,000,000**
Construction Contingency			$31,000,000
Construction Total			**$153,000,000**
Engineering, Legal, Fiscal			$37,000,000
Total Project Cost			**$190,000,000**
Notes: All cost estimates are in 2009 dollars. See Tables 15-6 through 15-11 for derivation of costs.			

15.4 Opinion of Costs: Option 3

Option 3: Lake Ontario intake utilizing existing pipeline segments; heat exchange facility near Seventh North Street (Figure 11-3).

Table 15-3. Option 3: Opinion of Project Costs

Item	Estimated Quantity	Unit Price	Opinion of Cost
New intake structure and wet well	1	$38,000,000	$38,000,000
New raw water pump station	1	$3,400,000	$3,400,000
New transmission line, 54-inch pipe (LF)	12,000	$480	$5,800,000
New transmission line, 42-inch pipe (LF)	74,000	$430	$32,000,000
New 30 mgd heat exchange/pumping facility	1	$7,000,000	$7,000,000
Chilled water buried piping, 36-inch pipe (LF)	16,000	$1,100	$18,000,000
Piping river crossings	0	$500,000	$0
Piping stream crossings	2	$150,000	$300,000
Piping state highway or railroad crossings	4	$300,000	$1,200,000
Piping wetlands crossings	2	$20,000	$40,000
Piping road way crossings, rural	3	$100,000	$300,000
Piping road way crossings, urban	5	$130,000	$650,000
Outfall cost	1	$1,000,000	$1,000,000
Subtotal			**$108,000,000**
Construction Contingency			$27,000,000
Construction Total			**$135,000,000**
Engineering, Legal, Fiscal			$35,000,000
Total Project Cost			**$170,000,000**
Notes: LF = Linear Feet All cost estimates are in 2009 dollars. See Tables 15-6 through 15-11 for derivation of costs.			

15.5 Opinion of Costs: Option 4

Option 4: Skaneateles Lake intake utilizing existing pipeline segments; heat exchange facility near Andrews Gatehouse Figure 11-4).

Table 15-4. Option 4: Opinion of Project Costs

Item	Estimated Quantity	Unit Price	Opinion of Cost
New intake structure and wet well	1	$42,000,000	$42,000,000
New raw water pump station	1	$1,00,000	$1,000,000
New transmission line, 54-inch pipe (LF)	0	$480	$0
New transmission line, 42-inch pipe (LF)	0	$430	$0
New 30 mgd heat exchange/pumping facility	1	$7,000,000	$7,000,000
Chilled water buried piping, 36-inch pipe (LF)	21,000	$1,100	$23,000,000
Piping river crossings	0	$500,000	$0
Piping stream crossings	2	$150,000	$300,000
Piping state highway or railroad crossings	4	$300,000	$1,200,000
Piping wetlands crossings	1	$20,000	$20,000
Piping road way crossings, rural	2	$100,000	$200,000
Piping road way crossings, urban	5	$130,000	$650,000
Outfall cost	0	$1,000,000	$1,000,000
Subtotal			**$76,000,000**
Construction Contingency			$19,000,000
Construction Total			**$95,000,000**
Engineering, Legal, Fiscal			$25,000,000
Total Project Cost			**$120,000,000**

Notes: LF = Linear Feet
All cost estimates are in 2009 dollars. See Tables 15-6 through 15-11 for derivation of costs

15.6 Opinion of Costs: Option 5

Option 5: Skaneateles Lake intake utilizing existing pipeline segments, with redundant potable flow from Lake Ontario (Figure 11-5).

Table 15-5. Option 5: Opinion of Overall Costs

Item	Estimated Quantity	Unit Price	Opinion of Cost
New intake structure and wet well	1	$42,000,000	$42,000,000
New raw water pump station	1	$1,00,000	$1,000,000
New transmission line, 54-inch pipe (LF)	0	$480	$0
New transmission line, 36-inch pipe (LF)	34,000	$430	$15,000,000
New 30 mgd heat exchange/pumping facility	1	$7,000,000	$7,000,000
Chilled water buried piping, 36-inch pipe (LF)	21,000	$1,100	$23,000,000
Piping river crossings	0	$500,000	$0
Piping stream crossings	3	$150,000	$450,000
Piping state highway or railroad crossings	6	$300,000	$1,800,000
Piping wetlands crossings	1	$20,000	$20,000
Piping road way crossings, rural	5	$100,000	$500,000
Piping road way crossings, urban	2	$130,000	$260,000
Outfall cost	0	$1,000,000	$1,000,000
Subtotal			**$92,000,000**
Construction Contingency			$23,000,000
Construction Total			**$115,000,000**
Engineering, Legal, Fiscal			$30,000,000
Total Project Cost			**$145,000,000**
Notes: LF = Linear Feet All cost estimates are in 2009 dollars. See Tables 15-6 through 15-11 for derivation of costs			

15.7 Preliminary Opinion of Construction Costs for Project Components

15.7.1 New Intake Structures and Wet Wells

The proposed intakes for both Skaneateles Lake and Lake Ontario consist of new concrete wet wells (Figure 15-1) on the shoreline connected to new end-of-pipe intake structures and screens at a distance of approximately 18,000 to 20,000 feet (5.5 to 6.1 km) from shore. The required distance from shore was similar for each lake, and represents the closest location where cold water was available based on lake depth. The new intake structure in the lake would be connected to the new wet well on shore by a 63-inch diameter HDPE intake pipe. The proposed pipe is the largest commonly manufactured pipe size appropriate to this type of construction, and will allow transmission of at least the 30 mgd design flow rate, even when allowing for impingement with age. Figures 11-9 (Lake Ontario) and 15-2 (Skaneateles Lake) show schematic details of the intake structures. Preliminary opinions of cost for the intake structures are given in Table 15-6.

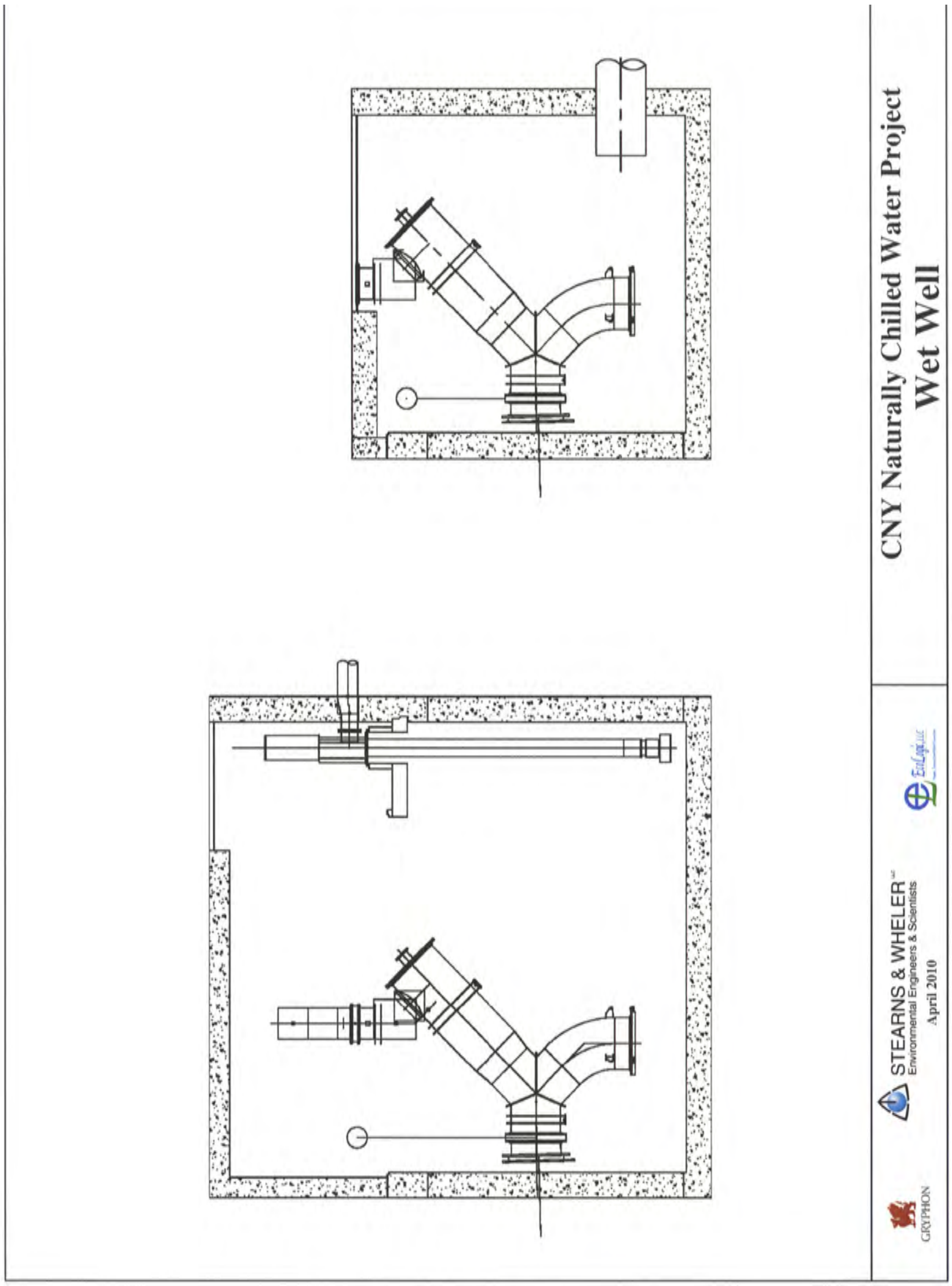
Table 15-6. Intake Structure And Wet Well Opinion Of Costs

Item	Estimated Quantity	Unit Price	Opinion of Cost
63-inch HDPE piping (LF)	20,000	$210	$4,200,000
Fusion welds on HDPE piping	400	$12,000	$4,800,000
Anchor blocks, concrete	1,535	$1,060	$1,600,000
Anchor block installation	1,535	$5,000	$7,700,000
Near shore dredging	1	$2,000,000	$2,000,000
Intake structure with screens	1	$8,000,000	$8,000,000
Marine equipment and installation services	1	$8,000,000	$8,000,000
Wet well	1	$1,500,000	$1,500,000
TOTAL			**$38,000,000**

Notes:

1. All cost estimates are in 2009 dollars.
2. Single intake pipe is approximately 20,000 feet (6.1 km) long, requiring 400 pieces of 50-foot HDPE piping.
3. One HDPE fusion weld required per piece of pipe.
4. Marine equipment and deployment item includes costs for the specialized barges, cranes, divers, and underwater installation equipment needed to install a 20,000-foot (6.1 km) submerged pipe and intake.
5. Skaneateles wet well will be complicated by the proximity of the existing highway. An additional $4 million was added to the Skaneateles-based options to account for this complication.

Figure 15-1. Preliminary Schematic of Wet Well, Required for All Chilled Water Options



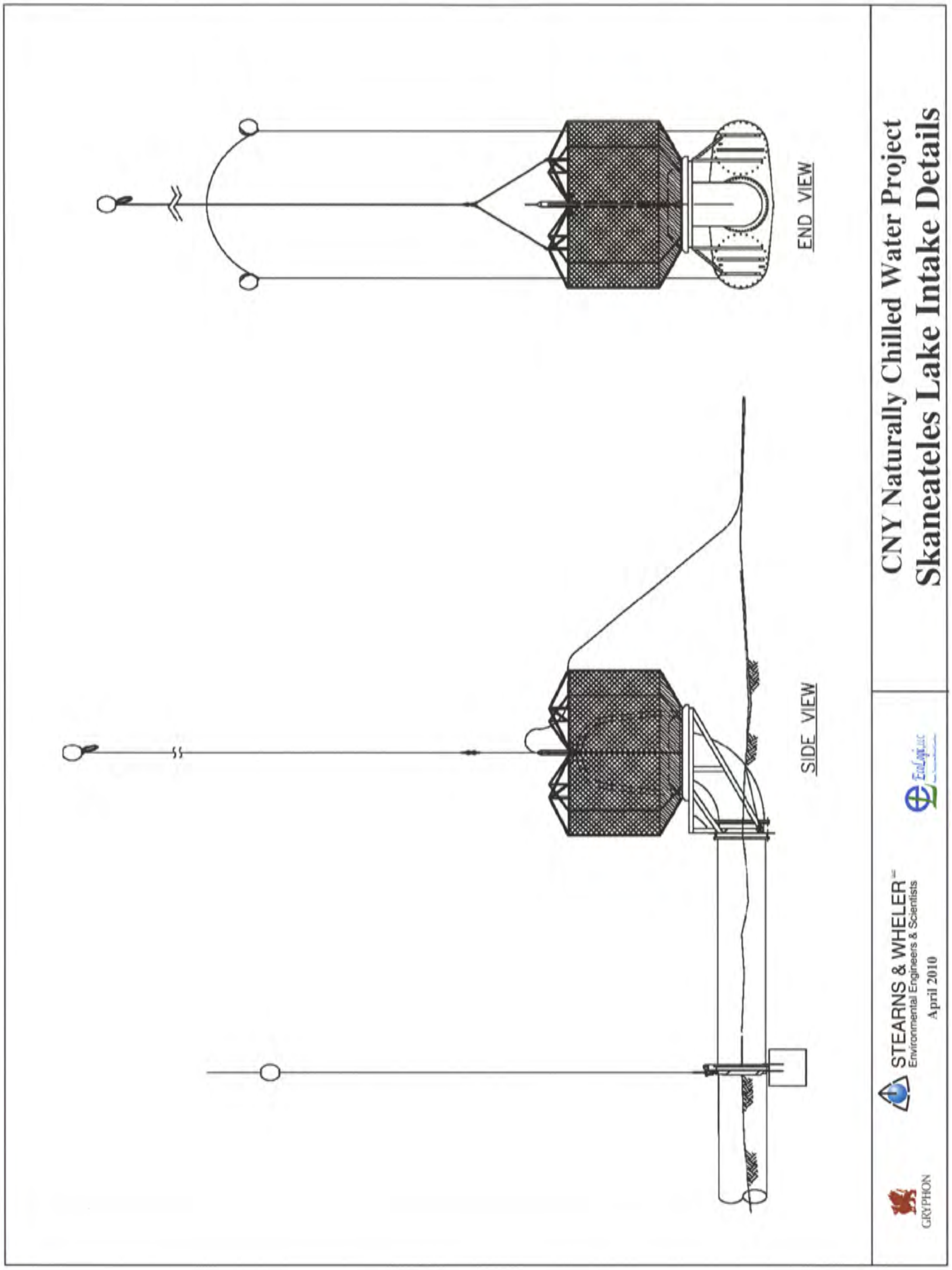


Figure 15-2. Details of Skaneateles Lake Intake Structure

The wet wells for either option consist of rectangular concrete shafts, as shown in Figure 15-1. Pumping station connected to the wet well will draw down the water level in the wet well to below the lake surface, inducing flow from the lake through the intake structure and submerged piping into the wet well. The operating water level in the wet well will need to be approximately 10 to 12 feet (3 to 3.7 m) lower than the lake surface in order to induce the required flows. Large diameter steel piping in either wet-well includes a port for the introduction of a pipe cleaning machine, which would likely be required at some point during the life of the project. See Table 15-6 (above) for preliminary opinions of cost for the wet wells.

15.7.2 New Lake Water Pumping Stations

A new pumping station will be required at the wet wells described above. The pumping station will draw water from the wet well and transfer it to transmission piping, providing the energy required to move it either to the MWB water treatment plant for the Lake Ontario options, or to the existing wet well in the Skaneateles Lake options. The number and size of pumps required to move the 30 mgd design flow will vary significantly from option to option, as explained below.

The Lake Ontario options include two variations:

- Option 1: A large pump station adjacent to the wet well sized to move the required 30 mgd flow to the heat exchange facility. The total pumping requirement for Option 1 is approximately 2,200 HP.
- Options 2 and 3. Each of these options would require a pumping station near the wet well of approximately 1,000 HP to move the required 30 mgd flow to the existing MWB water treatment plant which is approximately 2 miles (3.2 km) away. The existing MWB pumping station at the water treatment plant would then be used to move the water to the new heat exchange facility.
- Options 4 and 5. In Skaneateles, the required wet well pumping station will only need to add a few feet of head to the lake water to move it into the existing gravity conduit system for flow to the City of Syracuse. An initial estimate of the energy required is 100 HP. A pump station after the heat exchanger will be necessary to lift the thermally harvested potable water back into the city reservoir system.

Preliminary cost estimates for the lake water pumping stations are given in Table 15-7.

15.7.3 New 54-Inch and 42-Inch Transmission Piping

The various options make use of new 54- and 42-inch diameter transmission piping. These proposed piping segments would be ductile iron piping with cement lining. The piping segments would be buried at a depth of 5 feet (1.5 m) and generally run in close proximity to known utility piping in existing rights-of-way. The proposed routings of the new main transmission lines are mostly rural. The preliminary cost estimates in Table 15-8 include costs for the excavation, backfilling, compaction, grading, testing and restoration of the pipeline route, as well as the pipe material and installation costs.

Table 15-7. Lake Water Pumping Station Opinion of Construction Costs: Option 1

	Quantity	Opinion of Installed Cost (Each)	Opinion of Construction Cost	Remarks
1.0 Instrumentation and Control				
1.1 Control system hardware	1	$130,000	$130,000	A-B PLC
1.2 Initial programming	1	$90,000	$90,000	500 tag license plus programming
1.3 Human-machine interface	1	$75,000	$80,000	ZYCOM HMIs
1.4 Transmitters, pressure	16	$7,000	$110,000	In/Out from each pump, plus In/Out Facility
1.5 Transmitters, flow	9	$18,000	$160,000	In/Out Facility, and one per pump
1.6 Transmitters, temperature	2	$5,000	$10,000	In/Out Facility
Subtotal			**$580,000**	
2.0 Mechanical				
2.1 Main influent piping	1	$50,000	$50,000	54-inch main run x 100 feet
2.2 Branch piping runs, 18-inch	7	$50,000	$350,000	One per pump
2.3 18-inch check valves	7	$19,000	$130,000	One per pump
2.4 18-inch valves	14	$10,000	$140,000	Two per pump
2.5 Valve actuators, electric	14	$6,000	$80,000	Automated
2.6 Variable frequency drives	7	$45,000	$320,000	ABB or equivalent
2.7 Pipe insulation	1	$100,000	$100,000	Condensation
2.8 Pumps	7	$140,000	$980,000	Ingersoll Dresser J Line
Subtotal			**$2,200,000**	
3.0 Electrical				

Table 15-7. Lake Water Pumping Station Opinion of Construction Costs: Option 1 (Continued)

	Quantity	Opinion of Installed Cost (Each)	Opinion of Construction Cost	Remarks
3.1 480-volt distribution equipment	1	\$285,000	\$285,000	To each pump
3.2 Lights	1	\$40,000	\$40,000	Standard
3.3 Heat	1	\$15,000	\$15,000	Electric Heat
3.4 120-volt system	1	\$25,000	\$25,000	Work receptacles
3.5 Grounding	1	\$50,000	\$50,000	Through foundation
3.6 Power wiring	1	\$300,00	\$300,00	
3.7 Signal wiring	1	\$200,00	\$200,00	
Subtotal			**\$930,000**	
4.0 Site Work				
4.1 Building, 75 x 100	7,500 ft^2	\$250	\$1,900,000	\$250 per ft^2
4.2 Electrical service from pole	1	\$400,000	\$400,000	Based on recent project
4.3 Transformers	2	\$190,000	\$380,000	From JH cost estimate
4.4 Overhead crane	1	\$150,000	\$150,000	Motor/pump removal
4.5 Main electrical switch	1	\$80,000	\$80,000	15kV switch
4.6 Water, sewer	1	\$20,000	\$20,000	Bathroom/lockers
4.7 Fence	1	\$20,000	\$20,000	Site security
4.8 Paving	1	\$20,000	\$20,000	Four parking spots
Subtotal			**\$3,000,000**	
Estimated Opinion of Construction Cost (2009 US\$)			**\$6,700,000**	

Notes:1.The estimate of total cost shown above applies to Option 1.

2. Options 2 and 3 each require a reduced horsepower pump station than needed for Option 1, and the total cost for the smaller pump station is estimated at 50 percent of the Option 1 cost.

3. Options 4 and 5 require reduced horsepower pumps with an estimated total cost of \$1,000,000.

Table 15-8. 54- and 42-Inch Buried Piping Opinion of Unit Construction Costs

	Quantity	Opinion of Installed Cost (Each)	Opinion of Unit Construction Cost	Remarks
1.0 Basic Installation, 54-Inch, per Linear Foot of Pipe				
1.1 Pipe cost, 54-inch, ductile iron cement lined	1	$375	$375	Ductile iron pipe with mechanical joints, RS Means Site Work 2009, p. 439
1.2 Exterior pipe corrosion treatment	1	$20	$20	RS Means Site Work 2009, p. 432, $10.05 per linear foot for 24-inch diameter, doubled for 54-inch
1.3 Interior pipe corrosion treatment	1	$20	$20	Assumed equal to exterior protection costs
1.4 Trenching	1	$20	$20	Open trench, direct bury, RS Means Site Work 2009, p. 286, 12 feet deep with trench box, 1.0 cubic yard (CY) machine, 8 feet wide, $5.15 per CY, 3.5 CY per linear foot
1.5 Backfilling	1	$20	$20	RS Means Site Work 2009, p. 299, line 0020
1.6 Grading and hydro seeding	1	$25	$25	Spread topsoil, grade, hydroseed, RS Means Site Work 2009, p. 365, line 0400
Total, per Linear Foot of 54-Inch Piping			**$480**	
Total, per Linear Foot of 42-Inch Piping			**$430**	Assume 10 percent less than 54-inch
2.0 Extra Work				
2.1 Open road crossing, rural	1	$100,000	$100,000	Traffic control, paving, five days
2.2 Open road crossing, urban	1	$130,000	$130,000	Traffic control, paving, eight days

Table 15-8. 54- and 42-Inch Buried Piping Opinion of Unit Construction Costs (Continued)

	Quantity	Opinion of Installed Cost (Each)	Opinion of Unit Construction Cost	Remarks
2.3 Horizontal boring road crossing	1	$150,000	$150,000	150 feet, per RS Means Site Work 2009, p. 436, $645 per LF for 48-inch, adjusted to $677 for 54 inch, and add $45,000 for mobilization/ demobilization/traffic
2.4 Stream crossing, small	1	$150,000	$150,000	Same as horizontal boring
2.5 River crossing	1	$500,000	$500,000	Based on horizontal boring, but three times as long, Oneida, Oswego Rivers
2.6 State highway crossing, sleeved	1	$300,000	$300,000	Based on horizontal boring, double price to account for concrete sleeve, coordination and permits with state, and traffic control costs
2.7 Wetlands crossing	1	$20,000	$20,000	300 feet (91.5 m) long, direct bury, RS Means Site Work 2009, p. 286, 12 feet deep with trench box, 1.0 CY machine, 8 feet wide, $5.15 per CY, triple price to include backfill, compaction, dewatering and grading, 1,100 CY
2.8 Railroad crossing	1	$300,000	$300,000	Same as state highway crossing
Total, Extra Work				
Note: All cost estimates are in 2009 dollars				

15.7.4 New 36-Inch Chilled Water Piping Loop

The proposed chilled water loop consists of 36-inch diameter welded steel piping with interior corrosion lining and exterior insulation, and is based on a presumed flow rate of 30 mgd. The chilled water loop consists of two piping runs, supply and return, each 36 inches in diameter. These two piping runs would be buried in the same excavation. The proposed chilled water piping routes are under city streets in Syracuse, and the preliminary cost estimates contained in Table 15-9 include pavement cutting and demolition, excavation, trenching, backfill, compaction, paving, traffic control, and pipe material and installation costs.

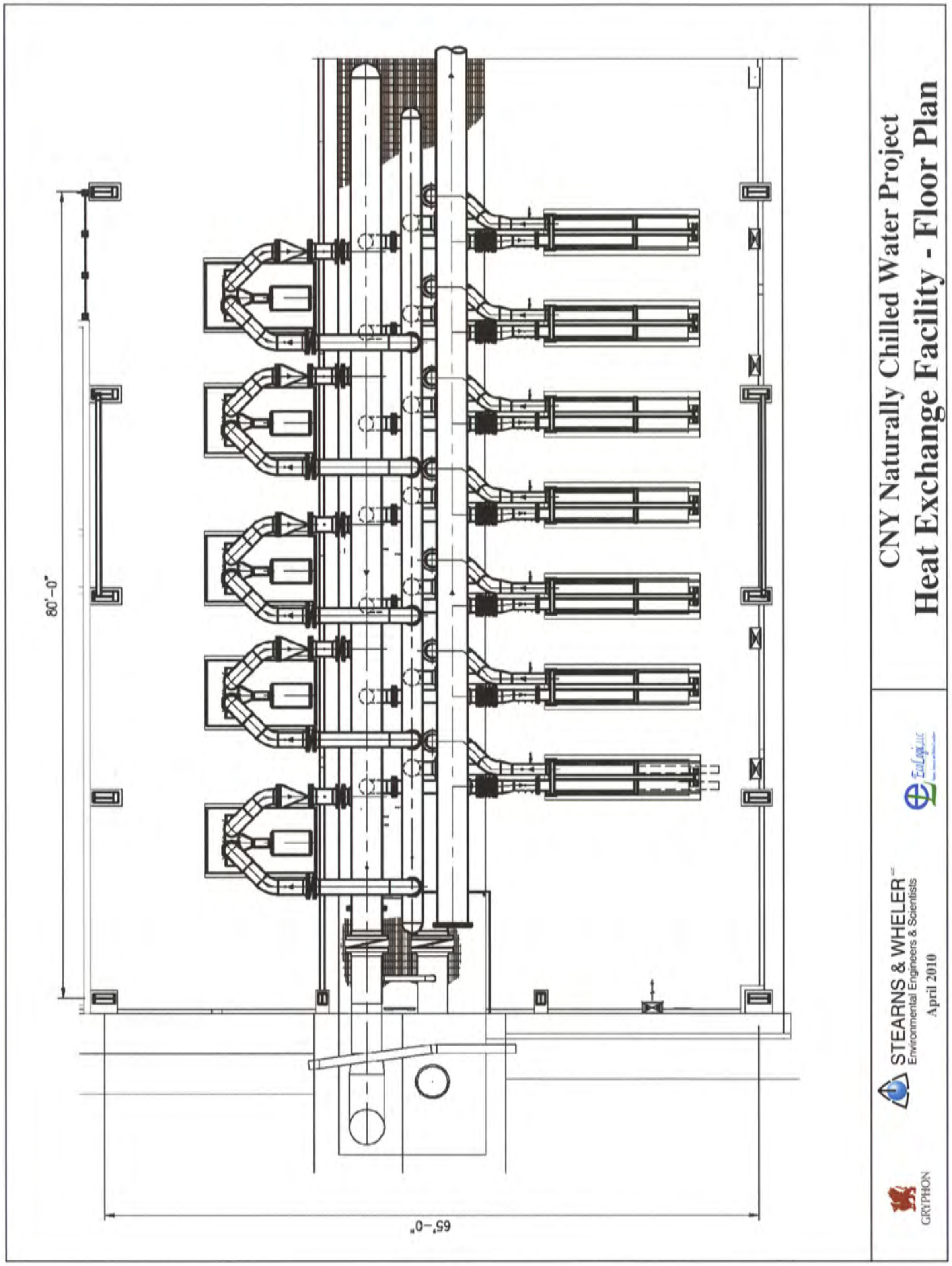
Table 15-9. 36-Inch Chilled Water Piping Opinion of Unit Construction Costs

	Quantity	Opinion of Installed Cost (Each)	Opinion of Unit Construction Cost	Remarks
1.0 Basic Installation, Double 36-Inch, per Linear Foot (LF)				
1.1 Pipe cost, 36-inch, 1/2-inch wall, two pipes	1	$910	$910	Welded connections, $455/ foot installed for each of two pipes, $910 total, based on RS Means Site Work 2009, p. 443
1.2 Exterior pipe corrosion treatment	1	$30	$30	RS Means Site Work 2009, p. 432, $10.05 per LF for 24-inch diameter, increased by 50 percent for 36-inch, doubled for two pipes.
1.3 Interior pipe corrosion treatment	1	$30	$30	Assumed equal to exterior protection costs.
1.4 Trenching	1	$25	$25	Open trench, direct bury, RS Means Site Work 2009, p. 286, 12 feet deep(3.7 m) with trench box, 1.0 CY machine, 10 feet (3 m) wide, $5.15 per CY, 4.4 CY per Linear Foot (LF)
1.5 Backfilling	1	$25	$25	RS Means, Site Work 2009, p 299 line 0020.
1.6 Paving	1.1	$80	$80	6-inch pavement replacement, RS Means Site Work 2009, p. 343, $69.5 per SY, 1.1 SY per LF
TOTAL per Linear Foot of 36-inch piping			**$1,100**	

15.7.5 New Heat Exchange Facility with Pump Station

The proposed heat exchange facility consists of plate-and-frame heat exchangers and a chilled water circulation pumping system, with all components sized for a 30 mgd flow rate. A building cross section and plan view are shown on Figures 15-3 and 15-4. The cost estimate in Table 15-10 includes the cost of a new building, heat exchangers, pumps, piping, valves, controls, and electrical service. The cost of land acquisition is not included in the cost estimate since it seems likely that the new facility would be located near existing city or MWB facilities where space for the new building may be available.

Figure 15-3. Floor Plan of Proposed Heat Exchange Facility



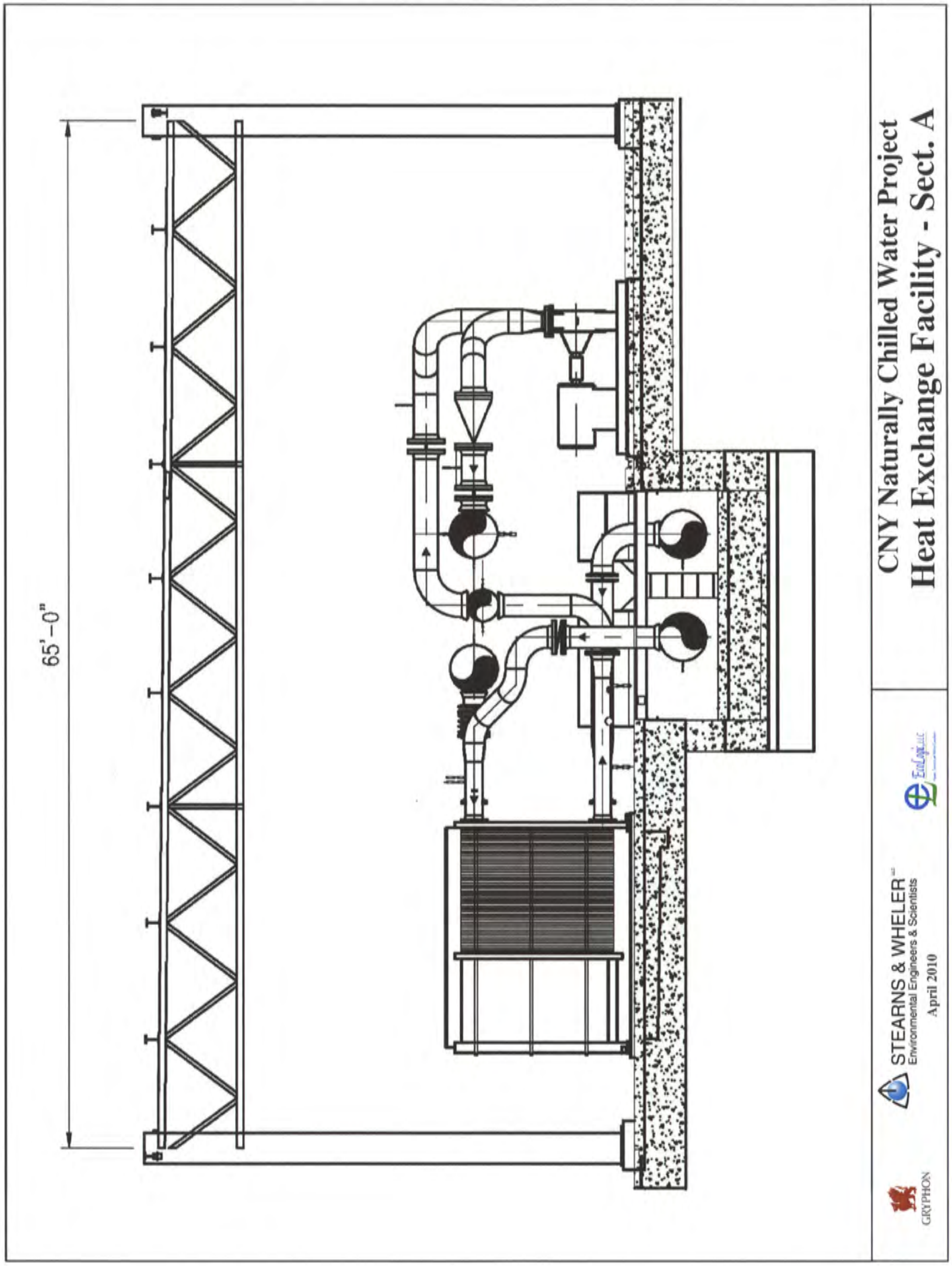


Figure 15-4. Cross Section Through Proposed Heat Exchanger Facility

Table 15-10. Heat Exchange / Pump Station Opinion of Construction Costs

	Quantity	Opinion of Installed Cost (Each)	Opinion of Construction Cost	Remarks
1.0 Instrumentation and Control				
1.1 Control system hardware	1	$130,000	$130,000	A-B PLC
1.2 Initial programming	1	$90,000	$90,000	500 tag license plus programming
1.3 Human-machine interface	1	$75,000	$75,000	ZYCOM HMIs
1.4 Transmitters, pressure	12	$7,000	$80,000	In/Out from each pump, plus In/Out Facility
1.5 Transmitters, flow	7	$18,000	$130,000	In/Out Facility, and one per pump
1.6 Transmitters, temperature	2	$5,000	$10,000	In/Out Facility
Subtotal			**$520,000**	
2.0 Mechanical				
2.1 Main influent piping	1	$50,000	$50,000	54-inch main run x 100 feet
2.2 Branch piping runs, 18-inch	5	$50,000	$250,000	One per pump
2.3 18-inch check valves	5	$20,000	$100,000	One per pump
2.4 18-inch valves	10	$10,000	$100,000	Two per pump
2.5 Valve actuators, electric	10	$6,000	$60,000	Automated
2.6 Variable frequency drives	5	$45,000	$230,000	ABB or equivalent
2.7 Pipe insulation	1	$100,000	$100,000	Condensation
2.8 Pumps	5	$140,000	$700,00	Ingersoll Dresser J Line
2.9 Heat Exchanger	1	$950,000	$950,000	
Subtotal			**$2,550,000**	
3.0 Electrical				

Table 15-10. Heat Exchange / Pump Station Opinion of Construction Costs (Continued)

	Quantity	Opinion of Installed Cost (Each)	Opinion of Construction Cost	Remarks
3.1 480-volt distribution equipment	1	$290,000	$290,000	To each pump
3.2 Lights	1	$40,000	$40,000	Standard
3.3 Heat	1	$20,000	$20,000	Electric Heat
3.4 120-volt system	1	$30,000	$30,000	Work receptacles
3.5 Grounding	1	$50,000	$50,000	Through foundation
3.6 Power wiring to equipment	1	$300,000	$300,000	
3.7 Signal wiring to instruments	1	$200,000	$200,000	
Subtotal			**$930,000**	
4.0 Site Work				
4.1 Building, 75 x 100	7,500 ft^2	$125	$950,000	$125 per ft^2
4.2 Electrical service from pole	1	$400,000	$400,000	Based on recent project
4.3 Transformers	2	$190,000	$380,000	From JH cost estimate
4.4 Overhead crane	1	$150,000	$150,000	Motor/pump removal
4.5 Main electrical switch	1	$80,000	$80,000	15kV switch
4.6 Water, sewer	1	$20,000	$20,000	Bathroom/lockers
4.7 Fence	1	$20,000	$20,000	Site security
4.8 Paving	1	$20,000	$20,000	Four parking spots
4.9 HVAC	1	$600,000	$600,000	
Subtotal			**$2,620,000**	
Estimated Opinion of Construction Cost, 2009 $US			**$6,620,000**	

Notes: 1. All cost estimates are in 2009 dollars
2. Costs estimated based on recent project costs for work in central New York in 2008/2009

15.7.6 New Outfalls

Several of the options include a new outfall to an existing water body to allow discharge of water after heat exchange. In Option #1, the entire amount of water withdrawn from Lake Ontario would be discharged to Onondaga Lake. In every other option, the amount of water discharged to an outfall would be very small since each of these options transfers most of the water to the potable system for use. Discharges to outfalls would only occur when cooling demands exceeded potable demands. The water to be discharged may be potable or non-potable, depending on the option and circumstances. Table 15-11 shows cost estimates for the outfall.

Table 15-11. Outfall Opinion of Construction Costs

Item	Estimated Quantity	Unit Price	Opinion of Cost
63-inch HDPE piping, Linear Foot (LF)	400	$210	$84,000
Fusion welds on HDPE piping	8	$12,000	$96,000
Anchor blocks, concrete	100	$1,000	$100,000
Anchor block installation	100	$2,000	$200,000
Near shore dredging	1	$150,000	$150,000
Diffuser structure	1	$200,000	$200,000
Marine equipment and installation services	1	$200,000	$200,000
54-inch piping from HX to shoreline (LF)	5,000	$480	$2,400,000
Total			**$3,400,000**

Notes:
1. All cost estimates are in 2009 dollars.
2. Cross country buried piping of 54-inch steel piping assumed for 5,000 Linear Feet from heat exchange facility to shoreline.
3. Submerged 63-inch HDPE piping 400 feet (122 m) into lake, connected to a diffuser assembly.
4. Submerged piping buried near shore, and then anchored to lake bottom farther from shore.
5. Marine equipment and deployment item includes costs for the specialized barges, cranes, divers, and underwater installation equipment needed to install the 400-foot (122 m) submerged pipe and intake.
6. Outfall costs for Options 2,3,4 and 5 are estimated at $1,000,000.

15.8 Section Summary

Opinions of construction costs for Options 1 through 5 are presented. Option 1 represents the highest construction cost at $250,000,000, while Option 4 represents the lowest construction cost, at $125,000,000. As will be shown in the next section, construction costs amortized over a 30 year period show the same trend.

16.0 Opinion of Operation and Maintenance Costs: Options 1-5

16.1 Section Introduction

Section 13 documented Opinions of Construction Costs for Options 1 - 5. In this section, we provide opinions for annual operating costs for each Option, and transform them into costs per ton of cooling delivered to a hypothetical customer. This in turn allows a comparison with actual operation costs from a large provider of mechanically-chilled water in the Syracuse region.

16.2 Annual Operation and Maintenance Costs

Each of the options considered will have annual operating costs for electricity, chemicals, personnel, maintenance, and other items. Interviews with the MWB and City of Syracuse staff were used to estimate how much labor material would be required to maintain the pump stations, transmission lines, and other equipment on an annual basis. Table 16-1 captures many of the expected costs and assigns cost estimates to each.

Table 16-1. Annual Operation and Maintenance Opinion of Costs

Item	Horse-power	Hours/Year	kWh/Yr	Opinion of Annual Cost
Option #1, Main Pump Station in Oswego	2,200	4,000	6,600,000	$800,000
Options #2/3 Main Pump Station in Oswego	1,500	4,000	4,500,000	$540,000
Options #4/5, Low lift pumps in Skaneateles	100	4,000	300,000	$40,000
Heat exchange facility	1,700	4,000	5,100,000	$600,000
Staffing and system maintenance				$2,600,000

Notes: 1. All cost estimates are in 2009 dollars.
2. Electricity costs estimated at $0.12 per kWh, delivered price.
3. Oswego Option #1 assumes 2,200 HP for 4,000 hours per year.
4. Oswego Options #2/3 assumes 1,500 HP for 4,000 hours per year.
5. Skaneateles Option #4 assumes 100 HP for 4,000 hours per year.
6. Heat exchange facility assumes 1,700 HP for 4,000 hours per year.
7. Staffing and maintenance costs reflect six full-time employees plus $2 million annual maintenance costs.

16.3 Preliminary Comparison: Delivered Cooling Costs

Each of the naturally chilled water options propose to bring 30 mgd of cold water to the City of Syracuse from either Lake Ontario or Skaneateles Lake, for the purpose of providing naturally chilled water for cooling to offset the need for mechanical chillers. The amount of cooling that can be delivered is constant, and capped by the limitations of the intake and/or conveyance structures. The amount of cooling needed varies based on weather and time of year. The economic benefit of the project as a whole depends on how much of the cooling delivered would be used by industries and commercial enterprises within the project area.

The capital cost of the infrastructure required to bring 30 MGD of cold water from one of the proposed sources to the City of Syracuse is the same if all of the cold water is used for cooling, or if none is. When project capital and O&M costs are reduced to a cost per delivered ton of cooling they can be compared to similar costs for large mechanically driven cooling systems. For the purposes of comparing delivered cooling cost we consider two alternatives:

1 25% of the total cooling available (based on 30 MGD flow) is used by customers;, and

2 100% of the total cooling capacity is used by customers.

Figures 16-1 and 16-2 show the estimated operations and maintenance (O&M) costs per ton of cooling delivered for each of these two alternatives. Tables 16-2 and 16-3 show the breakdown of O&M, capital, and total costs for each of the options and is the source of the data shown in Figures 16-1 through 16-4.

Clearly, any of the Options 1 - 5 are competitive with mechanical chillers in cost per ton of cooling delivered, at least in terms of O&M costs (Figures 16-1 and 16-2). In each of the comparisons, Option 4 provides the lowest cost per ton delivered. Option 5 differs by the cost of water purchased in that withdrawals from Skaneateles Lake are capped at 30 MGD irrespective of drinking water needs; drinking water requirements in excess of 30 MGD are purchased from the Metropolitan Water Board (See Tables 16-2 and 16-3).

Figure 16-1. Estimated O&M Cost per Ton of Cooling Delivered for Options 1 - 5 Compared to Current Syracuse University Chilled Water Plant. Costs Based on 25% Capacity.

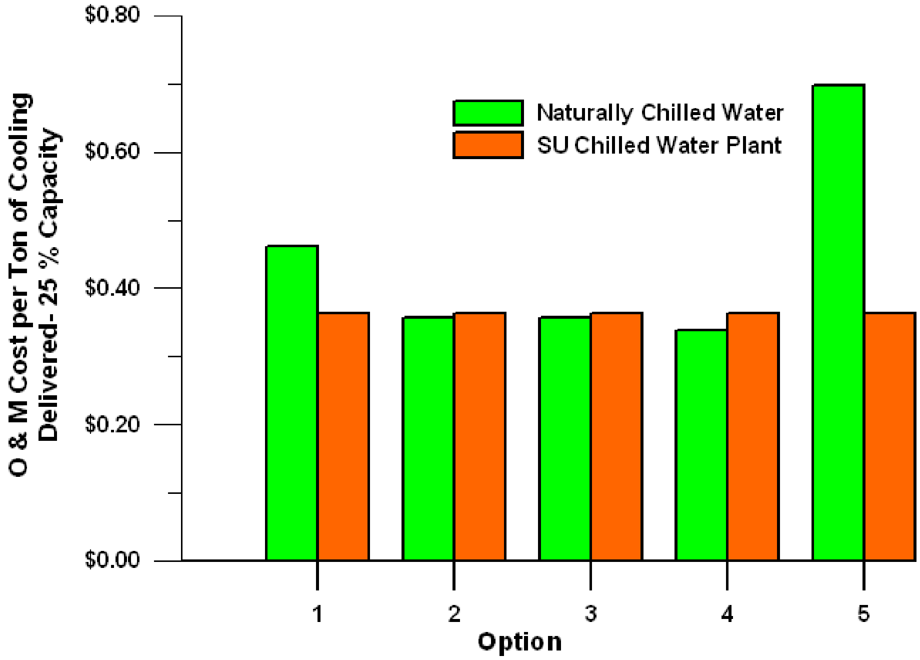


Figure 16-2. Estimated O&M Cost per Ton of Cooling Delivered for Options 1 - 5 Compared to Current Syracuse University Chilled Water Plant. Costs Based on 100% Capacity.

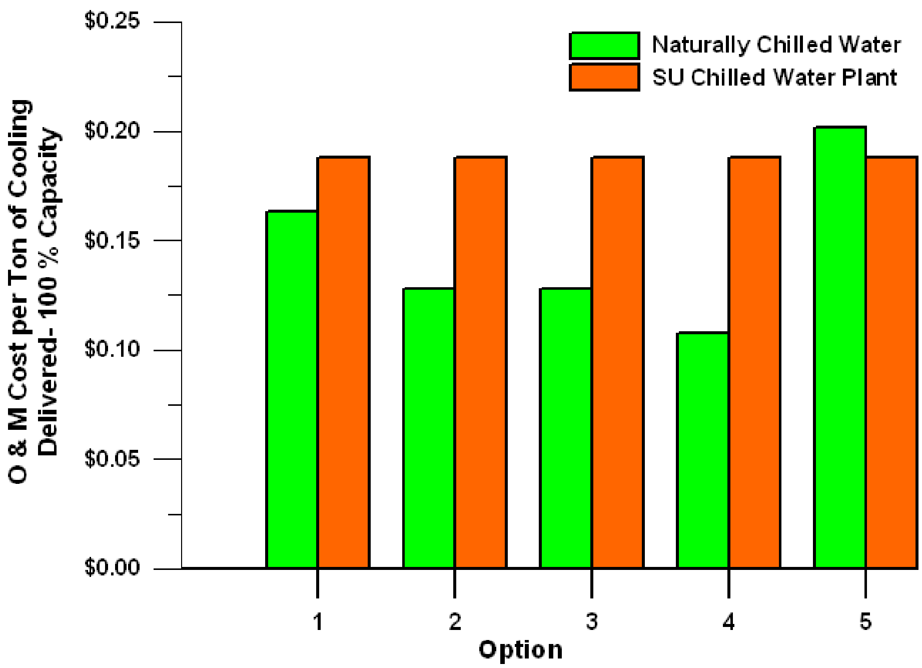


Figure 16-3. Estimated Total Cost per Ton of Cooling Delivered for Options 1 - 5 Compared to Current Syracuse University Chilled Water Plant. Costs Based on 25% Capacity.

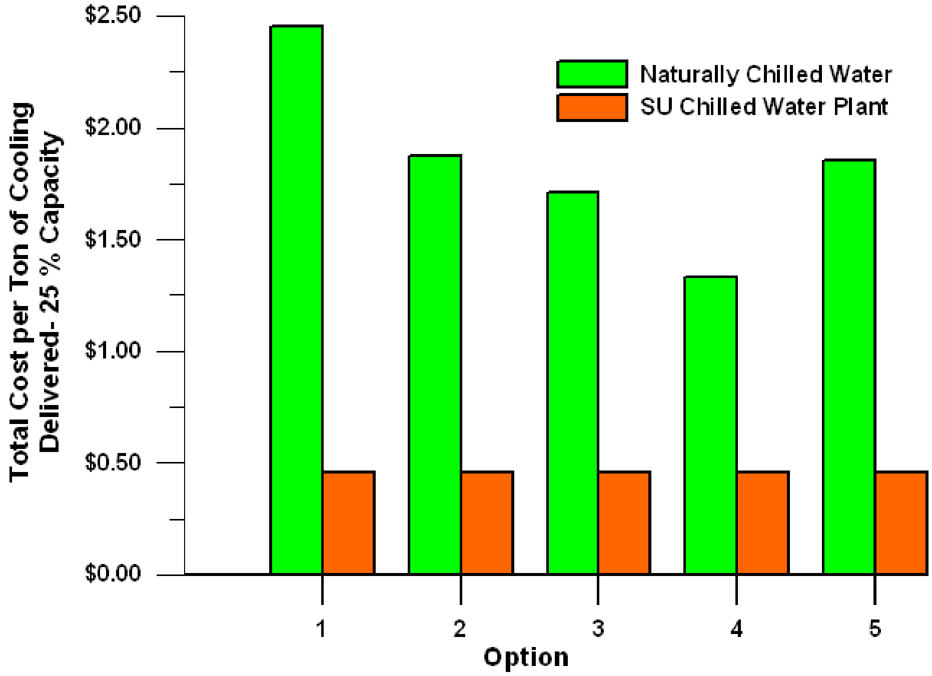
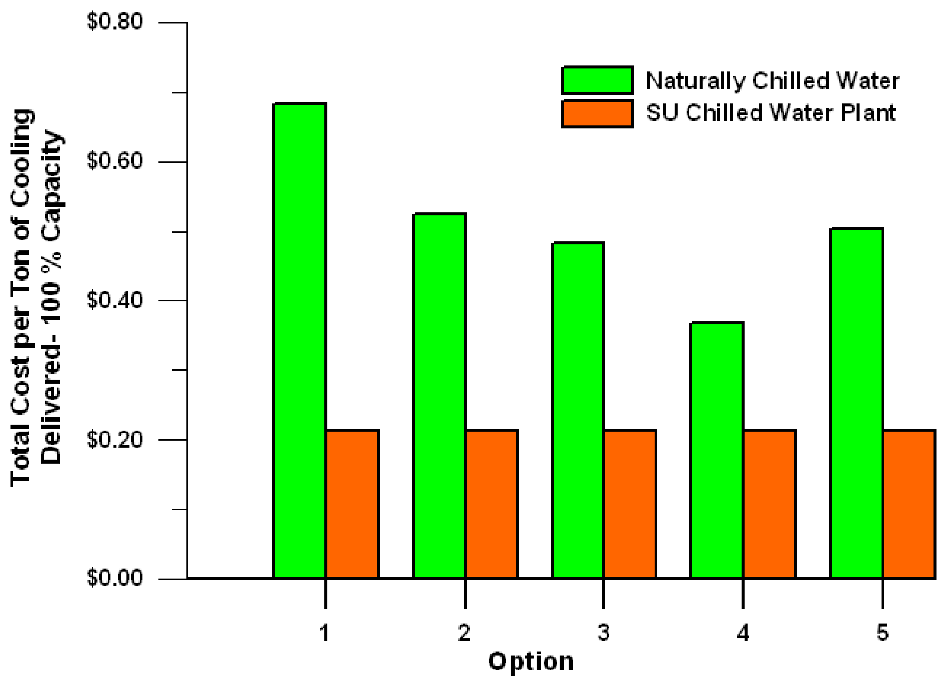


Figure 16-4. Estimated Total Cost per Ton of Cooling Delivered for Options 1 - 5 Compared to Current Syracuse University Chilled Water Plant. Costs Based on 100% Capacity.



The total cost comparisons (Figures 16-3 and 16-4) show a different story. In this comparison, the capital costs for each option are included. For the NCW options, the capital costs can be found in Tables 16-2 and 16-3, in the row labelled 30 year amortized cost. The O&M costs are added to get project total cost, on an annual basis. The total cost is then divided by the tons of cooling delivered to get the costs shown in Figures 16-3 and 16-4.

The costs for the SU Chilled Water Plant are also presented in Tables 16-2 and 16-3. The capital costs in this case include only the replacement costs for the mechanical chillers at the end of their useful life; replacement costs associated with the building and other infrastructure are not considered. For this reason, the comparison is advantageous to the existing mechanical chilled water plant in that the NCW options start from scratch for most of their associated infrastructure.

Again, Option 4 of the NCW options proves to be the least expensive alternative, under both the 25% and 100% scenarios, followed by Options 2, 3 and 5 all with similar costs. Option 1 is, by any comparison, the most expensive alternative.

The preliminary cost data presented here are useful on a comparative basis. However, the comparisons are limited by the following factors:

- the cost of electricity is assumed at a constant $0.12 per kWh,
- the value of energy savings and emissions reductions have not been considered,
- the value of a ‘green’ technology in terms of publicity and other green infrastructure issues has note been considered.

Some of these issues will be addressed in the next sections of the report.

Table 16-2.Range of Unit Costs to Customers at 25% of Capacity

Estimates	Option 1	Option 2	Option 3	Option 4	Option 5
	Lake Ontario, New Pipeline, Non-Potable, Heat Exchange at Seventh North Street	**Lake Ontario, Use Existing Pipeline, Potable, Heat Exchange at Terminal Reservoir**	**Lake Ontario, Use Existing Pipeline, Potable, Heat Exchange at Seventh North Street**	**Skaneateles Lake, Use Existing Conduits, Potable, Heat Exchange Near City**	**Skaneateles Lake, Use Existing Conduits, Add Southwest Branch, Heat Exchange near City**
Opinion of construction cost	$250,000,000	$190,000,000	$170,000,000	$125,000,000	$145,000,000
30-year amortized cost (30 years, 3%)	$12,750,000	$9,690,000	$8,670,000	$6,375,000	$7,395,000
Annual electrical costs	$350,000	$290,000	$290,000	$160,000	$160,000
Annual staffing/ maintenance costs	$2,600,000	$2,000,000	$2,000,000	$2,000,000	$2,300,000
Additional annual city purchased water from MWB	$0	$0	$0	$0	$2,000,000
Total Annual O&M Costs	**$2,950,000**	**$2,290,000**	**$2,290,000**	**$2,160,000**	**$4,460,000**
Total Annual Costs	**$15,700,000**	**$11,98,000**	**$10,96000**	**$8,535,000**	**$11,855,000**
Cooling delivered at 25% capacity (million tons)	6.4	6.4	6.4	6.4	6.4
Capital cost per ton of cooling delivered ($/ton)	$1.99	$1.51	$1.35	$1.00	$1.16

Table 16-2.Range of Unit Costs to Customers (Continued)at 25% of Capacity

Estimates	Option 1	Option 2	Option 3	Option 4	Option 5
	Lake Ontario, New Pipeline, Non-Potable, Heat Exchange at Seventh North Street	**Lake Ontario, Use Existing Pipeline, Potable, Heat Exchange at Terminal Reservoir**	**Lake Ontario, Use Existing Pipeline, Potable, Heat Exchange at Seventh North Street**	**Skaneateles Lake, Use Existing Conduits, Potable, Heat Exchange Near City**	**Skaneateles Lake, Use Existing Conduits, Add Southwest Branch, Heat Exchange near City**
O&M cost per ton of cooling delivered, at 25 capacity ($/ton)	$0.46	$0.36	$0.36	$0.34	$0.70
Total Naturally Chilled Water Unit Cost at 25% Capacity	**$2.45**	**$1.87**	**$1.71**	**$1.33**	**$1.85**
Current SU Chilled Water Plant Capital Cost ($/ton)	$0.09	$0.09	$0.09	$0.09	$0.09
Current SU Chilled Water Plant O&M Costs at 25% Capacity	$0.36	$0.36	$0.36	$0.36	$0.36
Current actual unit cost for mechanical chilling at SU chilled water plant ($/ton)	$0.46	$0.46	$0.46	$0.46	$0.46

Notes: 1. All cost estimates are 2009 dollars 2. Electrical, staffing, and cooling costs are all annual estimates.
3. Lake Ontario options assume 42°F (5.6°C) water delivered to heat exchanger, with a Δ T of 8°F (4,4°C) available for transfer.
4. Skaneateles Lake options assume 48°F (8.9°C) water delivered to heat exchanger, with a Δ T of 6°F (3.3°C) available for transfer.
5. Raw water flow rate for cooling calculations is 30 mgd.
6. Additional raw water purchased from MWB in Option 5 represents the annual cost to the City of Syracuse to purchase approximately 12 million gallons of potable water per day. In Option 5, the combined potable/chilled water flow from Skaneateles Lake is capped at 30 mgd, a reduction of about 12 mgd from historical levels.

Table 16-3. Range of Unit Costs to Customers at 100% of Capacity

Estimates	Option 1	Option 2	Option 3	Option 4	Option 5
	Lake Ontario, New Pipeline, Non-Potable, Heat Exchange at Seventh North Street	**Lake Ontario, Use Existing Pipeline, Potable, Heat Exchange at Terminal Reservoir**	**Lake Ontario, Use Existing Pipeline, Potable, Heat Exchange at Seventh North Street**	**Skaneateles Lake, Use Existing Conduits, Potable, Heat Exchange Near City**	**Skaneateles Lake, Use Existing Conduits, Add Southwest Branch, Heat Exchange near City**
Opinion of construction cost	$250,000,000	$190,000,000	$170,000,000	$125,000,000	$145,000,000
30-year amortized cost (30 years, 3%)	$12,750,000	$9,690,000	$8,670,000	$6,375,000	$7,395,000
Annual electrical costs	$1,400,000	$1,140,000	$1,140,000	$640,000	$640,000
Annual staffing/ maintenance costs	$2,600,000	$2,000,000	$2,000,000	$2,000,000	$2,300,000
Additional annual city purchased water from MWB	$0	$0	$0	$0	$2,000,000
Total Annual O&M Costs	**$4,000,000**	**$3,140,000**	**$3,140,000**	**$2,640,000**	**$4,940,000**
Total Annual Costs	**$16,750,000**	**$12,830,000**	**$11,810,000**	**$9,015,000**	**$12,335,000**
Maximum amount of cooling delivered (million tons)	24.5	24.5	24.5	24.5	24.5
Capital cost per ton of cooling delivered ($/ton)	$0.52	$0.40	$0.35	$0.26	$0.30

Table 16-3. Range of Unit Costs to Customers (Continued)at 100% of Capacity

Estimates	Option 1	Option 2	Option 3	Option 4	Option 5
	Lake Ontario, New Pipeline, Non-Potable, Heat Exchange at Seventh North Street	**Lake Ontario, Use Existing Pipeline, Potable, Heat Exchange at Terminal Reservoir**	**Lake Ontario, Use Existing Pipeline, Potable, Heat Exchange at Seventh North Street**	**Skaneateles Lake, Use Existing Conduits, Potable, Heat Exchange Near City**	**Skaneateles Lake, Use Existing Conduits, Add Southwest Branch, Heat Exchange near City**
O&M cost per ton of cooling delivered, at full capacity ($/ton)	$0.16	$0.13	$0.13	$0.11	$0.20
Total Naturally Chilled Water Unit 100% Capacity	**$0.68**	**$0.52**	**$0.48**	**$0.37**	**$0.50**
Current SU Chilled Water Plant Capital Cost ($/ton)	$0.02	$0.02	$0.02	$0.02	$0.02
Current SU Chilled Water Plant O&M Costs - 100% Capacity	$0.19	$0.19	$0.19	$0.19	$0.19
Current actual unit cost for mechanical chilling at SU chilled water plant ($/ton)	$0.21	$0.21	$0.21	$0.21	$0.21

Notes: 1. All cost estimates are 2009 dollars 2. Electrical, staffing, and cooling costs are all annual estimates.
3. Lake Ontario options assume 42°F (5.6°C) water delivered to heat exchanger, with a Δ T of 8°F (4,4°C) available for transfer.
4.. Skaneateles Lake options assume 48°F (8.9°C) water delivered to heat exchanger, with a Δ T of 6°F (3.3°C) available for transfer.
5.Raw water flow rate for cooling calculations is 30 mgd.
6. Additional raw water purchased from MWB in Option 5 represents the annual cost to the City of Syracuse to purchase approximately 12 million gallons of potable water per day. In Option 5, the combined potable/chilled water flow from Skaneateles Lake is capped at 30 mgd, a reduction of about 12 mgd from historical levels.

16.4 Section Summary

Capital and Operation and Maintenance costs for Options 1 through 5 are calculated and compared to an existing mechanically-chilled water plant in the Syracuse region. Each of the Naturally Chilled Water Options show lower O&M costs (exception: Option 5) as compared to the $0.19 or $0.36 per ton of cooling delivered by the mechanical plant (Figures 16-1, 16-2; Tables 16-3, 16-4).

The mechanical chillers, by the comparison presented here, are cheaper in total cost than any of the five Options. However, the comparison is limited in that only replacements costs for mechanical chillers were considered as compared to the entire capital costs for the NCW options.

By any comparison, Option 4 is the least expensive alternative, and Option 1 the most expensive. Options 2, 3 and 5 and close in total costs and between Options 1 and 4.

17.0 Expected Air Quality and Energy Savings Benefits

17.1 Section Introduction

One important goal of the Central New York Naturally Chilled Water Project (CNY NCWP) is to reduce energy consumption and the release of greenhouse gasses. Determining the overall reduction in emissions of CO_2, CH_4, NO_x, SO_x, (carbon dioxide, methane, oxides of nitrogen, oxides of sulfur, respectively) and particulates is an important component in assessing the feasibility of the project and is the purpose for this task.

17.1.1 Capital Costs, Operating Costs and the Value of "Green Technology"

Projected capital costs for a NCW system are substantial compared to replacing or repairing the existing mechanical chillers (Section 15 Opinions of Construction Cost: Options 1 - 5). While there are potential savings in operating costs in terms of dollars per ton of cooling delivered (Figure 16-1) these savings would not be enough to fully amortize startup costs. However, the amount of energy conserved has a value in addition to the direct unit cost. With each kilowatt-hour reduction, there is an equivalent amount of emissions avoided. Reductions in carbon and greenhouse gas emissions can improve air quality, but also have a monetary value if assigned a carbon credit (a dollar amount) to each ton of CO_2 that is avoided. The price of a carbon credit is often based on a market value, and so may change frequently. If the potential implementing entity places a high value on green technology and sustain ability, the inflated price of the carbon credit may be more attractive for the customer(s).

Two existing systems that utilize NCW for comfort cooling are described in detail in Section 3.0 Review of Two Naturally Chilled Water Systems. Design and engineering of the two projects are provided along with an analysis of actual energy savings. Other sections in this report provide calculated energy use and savings for the conceptual chilled water district.

The scope of this section is to compare conventional cooling systems, using mechanical chillers, to cooling using NCW. We conducted a quantitative analysis of the reductions in use and release of ozone-depleting chemicals, greenhouse gases, and energy that could be expected upon implementation of a NCW system.

The elements of this section include:

- Calculate the potential reduction in electricity use with the NCW system to predict the associated reduction in pollutants (CO_2, NO_X) emitted compared to conventional cooling.
- Based on decreases in CO_2 emitted directly and the equivalent CO_2 resulting from CH_4 and N_2O emissions, estimate the monetary savings from implementing a NCW system in terms of carbon credits.
- The release of greenhouse gases, such as CO_2, have been implicated in climate change. Other greenhouse gases can be converted to an equivalent amount of CO_2 based on how they affect the earth atmosphere. Therefore, we converted CH_4 and N_2O emissions into an equivalent amount of CO_2 for our use in the energy savings and emission reduction calculator. We used a pollution factor of 21 for CH_4 and 310 for N_2O (i.e. CH_4 is 21 times more potent than CO_2 as a greenhouse gas). These values are Climate Registry published values.
- Based on the calculated emission rates of conventional chillers, we compared the calculated emission rates for each NCW option (1-5). We computed these savings assuming electricity generation from the combustion of 14% coal and 100% coal. We also computed emission rates assuming 100% coal combustion for comparison.

17.2 Development of the Emissions Calculator

We created an energy conversion calculator to estimate emissions that could be avoided using NCW for comfort cooling in CNY. The energy converter uses the annual electricity usage in kWhs for both the conventional and the NCW system. This input is the basis for a series of calculations that show the emissions each NCW option would produce.

The energy used by the conventional cooling system considers electric chillers, ancillary equipment, and distribution pumps. An estimate was derived from data taken at the Syracuse Chilled Water Plant and is the energy required to produce about 5 million tons of cooling over the 6-month cooling season. The projected energy requirements for the 5 NCW Options are derived from data presented in Section 15.0 Opinions of Costs: Options 1-5. The estimate for each option considers the energy required at the pump station on the source water body and heat exchange facility in the chilled water district. Energy requirements were adjusted according to chilled water loop length.

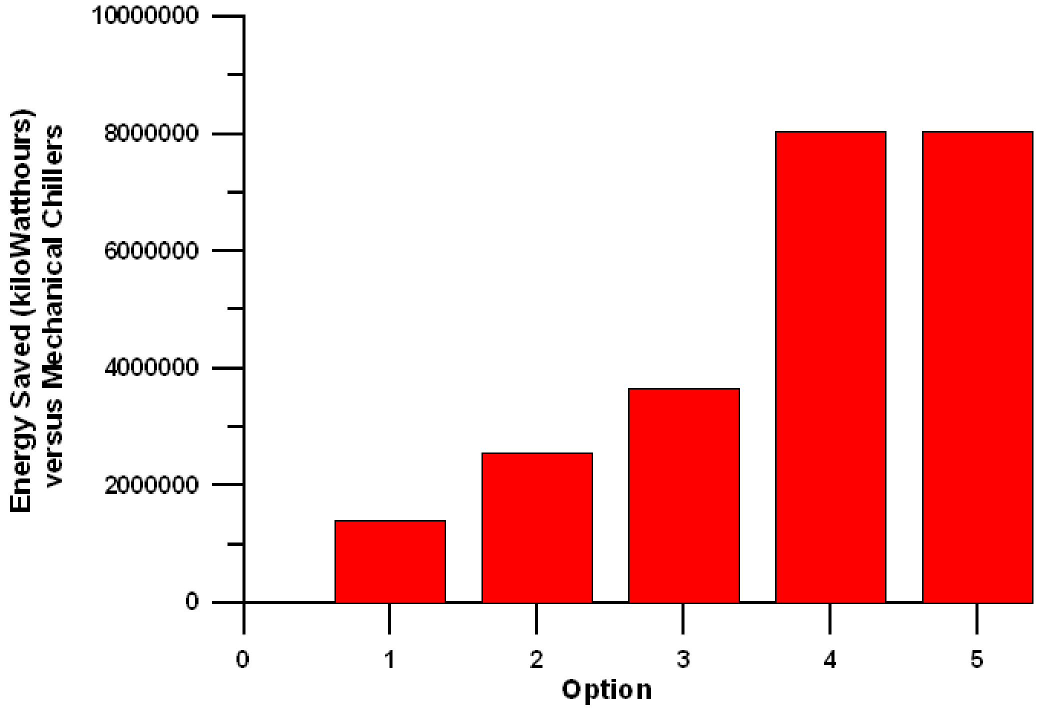
Data from the Natural Mining Association was used to determine the percentages of CNY power that are taken from coal and natural gas (National Mining Association 2008). Electricity created from each fuel type was converted into the grams of CO_2, SO_x, NO_x, and particulates emitted; subsequently, these were converted into pounds and tons. In order to illustrate the savings conceptually, the amount of CO_2 avoided was converted into an equivalent amount of cars and light trucks that could be "taken off the road" based on the average CO_2 emitted by these vehicle types per year (EPA 2000).

Two methods were used to generate a dollar value for avoided emissions. The first method was based upon the price of a Certified Emission Reduction (CER) during October 2009 (Hamilton 2009). The other price metric was calculated from Climate Registry data. The Climate Registry is a non-profit collaboration that sets consistent standards to calculate, verify and publicly report greenhouse gas emissions in a single registry (The Climate Registry 2008). This price considers an equivalent amount of CO_2 based on CO_2, CH_4 and N_2O, corresponding to their global warming potential. The total corresponding tons of CO_2 were converted to an equivalent amount of cars and light trucks taken off the road by the same method outlined above. In addition, the equivalent tons of CO_2 were converted into a dollar value based on the price proposed by the Regional Greenhouse Gas Initiative from the Climate Registry. Taking the difference between all of these values for conventional and NCW cooling, the potential savings from this project were calculated.

17.3 Energy Savings and Avoided Emissions

The output from the conversion calculator is presented in this subsection. Data calculated for the five options suggests a potential energy savings ranging from 1.4 to 8 million kWhs for the five NCW Options considered (Figure 17-1). Options 4 and 5 would save the largest amount of energy over conventional chillers. This savings is a reflection of the avoided pumping energy due to gravity flow from Skaneateles Lake and the relatively shorter chilled water loop considered in Options 4 and 5.

Figure 17-1. Energy Savings (kilowatt-hours) by Option Compared to Mechanical Chillers



The information shown in Figure 17-1 is subject to the following assumptions:

1 Energy usage for both the mechanical chillers and each of the options was increased by 7% to account for losses in transmission. The data therefore represent avoided electricity generation.

2 Energy used for conventional chillers assumes a cooling demand of 5 million tons (from Syracuse University chilled water plant data).

3 Energy used in Naturally Chilled Water cooling considers energy used at pump stations, heat exchange facilities, and chilled water loops corresponding to each NCW Option.

4 Energy used for mechanical chillers and NCW assumes 6 month operation per year, during the cooling season.

The energy saved in the chilled water options was converted to an equivalent amount of emitted pollutants that could be avoided by the reduction in energy generation. Emissions in tons of carbon dioxide (CO_2), oxides of sulfur (SO_x), oxides of nitrogen (NO_x), and particulates avoided are presented in Table 17-1 and Figures 17-2 and 17-3. We calculated two values for each option and type of emission considered. The first value represents the amount of pollutants avoided considering energy generation by 14% coal and 31% natural gas. This is the reported method of energy generation for CNY during base energy consumption. The second value, based on 100% of electrical generation from coal, may be a more appropriate number during peak energy usage and for areas that would be closer to coal burning power plants.

Using the exchange dollar value of CERs, a value was calculated for each NCW options and energy origin. With estimates ranging from a low of $8,400 to a high $160,000 annually, the avoided emissions represent an incentive and benefit of a CNY Naturally Chilled Water Project.

Table 17-1. Avoided Emissions and Associated Value of Carbon Credits by Option

Annual Avoided Emissions (tons) by Energy Source for Electricity Generation		Option				
		1	2	3	4	5
CO_2	14% coal, 31% natural gas	410	740	1,100	2,300	2,300
	100% coal	1,300	2,400	3,400	7,600	7,600
SO_x	14% coal, 31% natural gas	0.55	0.99	1.4	3.1	3.1
	100% coal	3.9	7.1	10	22	22
NO_x	14% coal, 31% natural gas	0.76	1.4	2.0	4.3	4.3
	100% coal	3.7	6.8	9.7	21	21
Particulates	14% coal, 31% natural gas	0.022	0.040	0.057	0.13	0.13
	100% coal	0.12	0.23	0.32	0.71	0.71
Values of avoided CO_2	14% coal, 31% natural gas	$8,400	$15,000	$22,000	$48,000	$48,000
	100% coal	$27,000	$50,000	$71,000	$160,000	$160,000
Note: Dollar value of avoided CO_2 emissions based on the October 2009 price given in the Certified Emission Reduction program						

Figure 17-2. Avoided Carbon Dioxide Emissions by Option and Energy Source for Electricity Generation

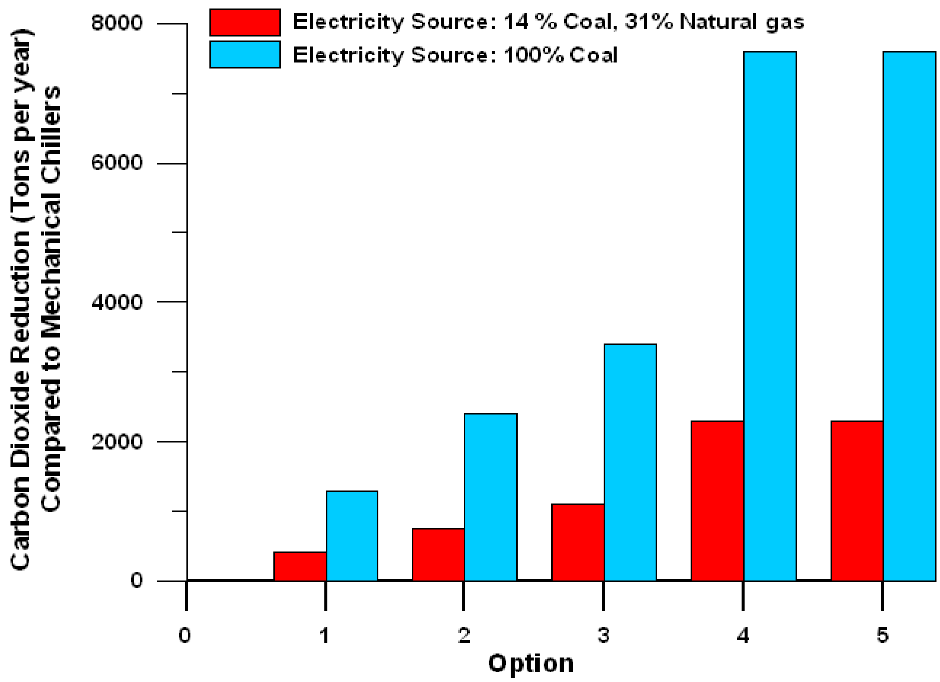
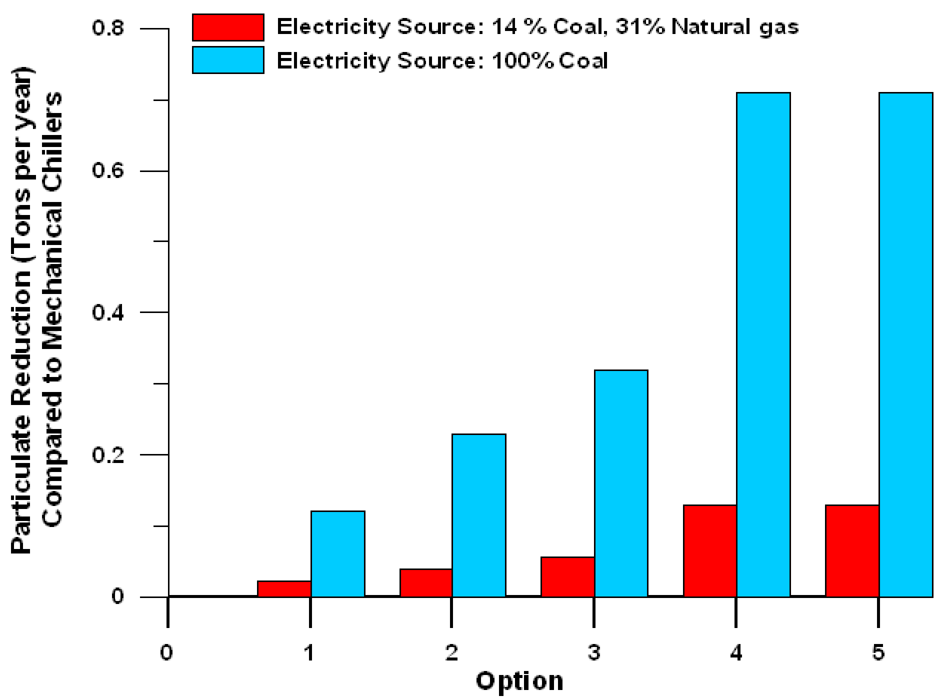


Figure 17-3. Avoided Particulate Emissions by Option and Energy Source for Electricity Generation



Alternative figures for avoided emissions were calculated using data from The Climate Registry (Table 17-2). Using these values, an equivalent amount of avoided CO_2 corresponding the global warming potential of CO_2, CH_4, and N_2O was calculated for each option. The Regional Greenhouse Gas Initiative Price was used to calculate a monetary value of the avoided emissions. Monetary values associated with carbon are based on a carbon tax price, which is expected to fluctuate. Additionally, customers may opt to apply an artificially high price based on their value of "green technology."

Using the equivalent amount of avoided CO_2 calculated for each option the number of vehicles that could be "removed from the road" was calculated.

Table 17-2. Equivalent Avoided Emissions of CO_2, and Associated Value

Equivalent Value of Avoided Emissions		**Option**				
		1	**2**	**3**	**4**	**5**
Climate Registry Calculations	$CO_{2(e)}$ avoided (tons)	580	1,100	1,500	3,300	3,300
	RGGI Price of CO_2	$1,600	$2,900	$4,100	$9,000	$9,000
	Passenger cars	100	180	260	580	580
	Light trucks	73	130	190	410	410

Note: $CO_{2(e)}$ = sum of CO_2 and CO_2 equivalents of CH_4 and N_2O emissions
RGGI = Regional Greenhouse Gas Initiative

17.4 Considerations

The current CER price is relatively low, and CERs are subject to market forces, and a relatively volatile price index. If the price of CERs were to rise, whether from the institution of cap and trade or government regulations the value of emission reductions from a NCW Project would increase. A higher value associated with avoided emissions could affect the economic feasibility of a chilled water system in CNY.

The proportion of different energy sources used in New York State will change over time and the rate of emissions will change accordingly. This could affect the environmental benefit of using NCW depending on whether cleaner or more polluting energy sources are used. During normal operation and a constant rate of electricity usage, generation power plants, or baseload plants are used to generate a constant supply. During peak electricity use, such as during summer months, additional (peaking) power plants must be brought online in order to meet the increased electricity demands. Often, these peaking plants are older and less efficient than the base load plants because they are used less frequently and may be outdated. Coal plants are commonly used as peaking plants. The energy generated during the summer months in Central New York is represented here by peaking plants or 100% coal and by baseload plants, or 14% coal, 31% natural gas.

There is an estimated 7% loss of the total energy generated from a power plant due to losses in electrical transmission lines, transformers, etc. These transmission losses were taken into consideration in the calculation shown in Table 17-1 and Figures 17-2 and 17-3.

The Naturally Chilled Water Project would be designed for a 100-year lifespan while conventional chillers are only designed for about 45 years. This design benefit not only saves money in reduced insulation and material costs but also results in a reduction in fossil fuel consumption. The extended lifespan of the NCW system reduces material use, chiller construction, and transport. Mechanical chillers require fossil fuels to build and transport, and the longer lifespan of the NCW will decrease fossil fuel use. These considerations are beyond the scope of this section but add to the potential benefits of a NCW system over conventional chillers.

The two different dollar values calculated for avoided emissions differed by a factor of ten. This is caused by the pricing index of a CER versus the RGGI price. The price of a CER is based on a traded market value in Europe. Therefore, CER price may change with demand for carbon credits and is consequently a relatively unstable price index. In addition, Europe generally has more stringent environmental regulations and a greater public concern for environmental issues. Therefore, carbon credits in Europe are currently priced higher than in the US. The second monetary metric, the RGGI price, has different factors that contribute to its value. This price is based on how much a state is willing to pay one another for traded credits. This arbitrary price is much lower than the European CER price. Since these two metrics have different origins (CERs are based off of market demand, while RGGIs are a standard set by carbon-trading states), they have different prices and the dollar values presented reflect these differences.

17.5 Section Summary

The principal findings of this section indicate that the potential environmental benefits of a NCW system are real and could be substantial. Because the calculations are based on changing values, such as carbon credits and personal vehicle emissions, the savings on emissions, cars, and money are subject to changes as market prices fluctuate.

The CNY NCWP achieves modest reductions in emissions. While these reductions are a relatively small percentage of the total U.S. emissions, this project will be a step in the right direction in terms of sustainability and controlling regional greenhouse gas emissions.

17.6 Literature Cited

The Climate Registry. 2008. General Reporting Protocol for the Voluntary Reporting Program.

Hamilton, Ian. 2009. CER prices reach 2009 highpoint. Accessed November 23, 2009 from Carbon Positive: http://www.carbonpositive.net/viewarticle.aspx?articleID=1705

Israel Electric Corporation Ltd. 2008. Environmental Report. Accessed November 15, 2009.

National Mining Association. 2008. Coals in New York. Accessed November 15, 2009 from America's Power: Coal Provides Jobs and Affordable Electricity: http://www.nma.org/pdf/americas_power_states/NY.pdf

USEIA (United States Energy Information Administration). 2009. Voluntary Reporting of Greenhouse Gases Program. Accessed November 15, 2009.

USEPA (United States Environmental Protection Agency). 2000. Emission Facts: Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks. EPA420-F-00-013.

18.0 Sensitivity Analysis

18.1 Section Introduction

Given the size and scope of the Central New York Naturally Chilled Water Project (CNYNCWP), it was determined that a sensitivity analysis should be performed to evaluate the effect of a number of cost variables on the economic favorability of the project. The variables that are included in the following analysis include the cost of electricity, the value of emissions reductions, the value of federal grants or tax incentives for clean energy technologies, and the value of infrastructure redundancy for the regional water authority. These variables were ascertained to have the greatest likely effects on the project's capital costs and operating costs.

18.1.1 Electricity Costs

The energy used by existing mechanical chillers to be replaced by a NCW system considers electric chillers, ancillary equipment and distribution pumps. An estimate was derived from data taken at the Syracuse Chilled Water Plant and is the energy required to produce about 5 million tons of cooling over the 6-month cooling season. The 5 NCW Options would consume electricity to operate distribution pumps and ancillary equipment. The projected energy requirements for the 5 NCW Options are derived from data presented in Section 15.0 Opinions of Costs: Options 1-5. Projected increases in the unit price ($/kWh) of electricity can be expected to provide a modest improvement in relative cost for the NCW system as compared to existing mechanical chillers.

18.1.2 Value of Emissions Reductions

Projected capital costs for a NCW system are substantial compared to replacing or repairing the existing mechanical chillers (Task 5). While there would be savings in operating costs, in terms of dollars per kilowatt-hour (kWh), these annual savings would not be enough to fully amortize startup costs. However, the amount of energy conserved has a value in addition to the direct unit cost. With each kilowatt-hour reduction, there is an equivalent amount of emissions avoided. Reductions in carbon and greenhouse gas emissions can improve air quality, but also have a real monetary value if assigned a carbon credit (a dollar amount) to each ton of CO_2 that is avoided. Given the modest reductions in emissions to be gained from utilization of the NCW system, the income to be received from the marketing of carbon credits can only be expected to provide a slight improvement in relative cost for the NCW system as compared to existing mechanical chillers.

18.1.3 Value of Federal Grants or Tax Incentives

The substantial projected capital costs for a NCW system can be offset by federal grants or tax incentives that may become available in the future. While current federal programs such as U.S. Department of Treasury Renewable Energy Grants, which provide up to 30% of eligible renewable energy property, authorized by H.R. 1: Div. B, Sec. 1104 & 1603 (The American Recovery and Reinvestment Act of 2009) cannot be used for NCW systems, it is possible that future programs could provide financial incentives. Depending on the level of incentive provided, federal support could greatly improve the relative cost for the NCW system as compared to existing mechanical chillers.

18.1.4 Value of Infrastructure Redundancy for Regional Water Authority

NCW Option 1 is the original project concept and considers a new deep water intake, pumping station, transmission pipeline from Oswego to the City of Syracuse, heat exchanger, and chilled water loop to serve customers in the University area. The raw water from the new deep water intake would not be treated to potable standards and would remain completely separate from the potable water system. There is reason to expect that the regional water authority might be willing to shoulder some of the startup cost of the NCW system in return for the benefit of access to redundant infrastructure. Depending on the level of local contribution, support from the regional water authority could greatly improve the relative cost for the NCW Option 1 system compared to existing mechanical chillers.

18.1.5 Benefit of Performing Sensitivity Analysis

Performing a sensitivity analysis can provide valuable information to decision-makers in evaluating under which conditions a NCW system might compare favorably on a cost basis with existing mechanical chillers. As with all such analyses, care must be exercised in the evaluation of the results presented below as the assumptions upon which the analysis are based is made by using projections using best available data as well as past experience/data which may not hold in the future. However, the information presented below may help to determine a strategic course of action in identifying and securing needed financial support for a NCW system.

18.2 Development of the Sensitivity Model

18.2.1 Unit Cost of Electricity

We first examined the impact of projected increases in the unit cost ($/kWh) of electricity. Using data on New York State commercial energy prices over the period 1994-2008 (in nominal dollars) as reported by the New York State Energy Research and Development Authority (NYSERDA) in its Patterns and Trends: New York State Energy Profiles, 1994-2008 report, it was found that the average rate of inflation over that 15-year period was 2.895%. At that rate of inflation, average commercial electricity prices in New York State are projected to reach $0.24/kWh in 2021, $0.36/kWh in 2035, and $0.48/kW in 2045.

Given the expected 100-year lifespan of a NCW system, it is important to consider the dramatic increases in operating costs to be expected over this time frame. If the rate of inflation experienced during 1994-2008 were to remain constant through the year 2110, the average unit price of electricity during that 100-year span would be approximately $1.04/kWh. If the rate of inflation were to be 4% over that 100-year span, then the average unit price of electricity would be approximately $2.32/kWh.

18.2.2 Value of Emissions Reductions

The next factor to be considered was the income to be received from the marketing of carbon credits or certificates which could be used to offset the operating costs of the NCW system, and thus make it more advantageous on a cost basis as compared to the use of existing mechanical chillers. Using information presented in Chapter X, the electricity usage of NCW Options 1-5 was compared to that derived from the use of mechanical chillers in the targeted area of the Syracuse downtown business district and University Hill, at both full utilization rates within this area as well as the more likely 50% utilization rate.

We next utilized the U.S. Environmental Protection Agency Emissions & Generation Resource Integrated Database (eGRID) database and calculator to convert the kWh savings from utilization of the NCW system into corresponding avoidance of GHG emissions for CO2, SOX, and NOX. The eGRID tool is the preeminent source of air emissions data for the electric power sector, and is based on available plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. government. eGRID integrates many different federal data sources on power plants and power companies, from three different federal agencies: EPA, the Energy Information Administration (EIA), and the Federal Energy Regulatory Commission (FERC). Emissions data from EPA are carefully integrated with generation data from EIA to produce useful values like pounds per megawatt-hour (lb/MWh) of emissions, which allows direct comparison of the environmental attributes of electricity generation. eGRID also provides aggregated data by state, U.S. total, company, and by three different sets of electric grid boundaries.

Table 18-1.Results of Sensitivity Analysis: Reduction in Emissions

	Mechanical chillers	Option 1	Option 2	Option 3	Option 4	Option 5
Electricity Usage (kWh) - Full utilization	37,610,722	23,200,000	19,100,000	19,100,000	10,700,000	10,700,000
Electricity Usage (kWh) - 50% utilization	18,805,361	23,200,000	19,100,000	19,100,000	10,700,000	10,700,000
Electricity Usage Displaced by NCW System (kWh) - Full utilization		14,410,722	18,510,722	18,510,722	26,910,722	26,910,722
CO_2 Avoided (tons)		5,015	6,442	6,442	9,365	9,365
SOx Avoided (tons)		20.9	26.86	26.86	39.05	39.05
NOx Avoided (tons)		5.6	7.43	7.43	10.8	10.8
Number of passenger vehicles equivalent to tons of CO_2		959	1,232	1,232	1,791	1,791
Electricity Usage Displaced by NCW System (kWh) - 50% utilization		(4,394,639)	(294,639)	(294,639)	8,105,361	8,105,361
CO_2 Avoided (tons)					2,821	2,821
SOx Avoided (tons)					11.76	11.76
NOx Avoided (tons)					3.25	3.25
Number of passenger vehicles equivalent to tons of CO_2					539	539

18.2.3 Value of Federal Grants or Tax Incentives

The potential future value of federal grants or tax incentives must be presently assumed, as there are no current programs that would provide financial support for a NCW system. Currently, the Renewable Energy Grant offered by the U.S. Treasury Department in lieu of tax credits provides up to 30% of the cost of eligible renewable energy property such as photovoltaic or small wind energy systems. For the purposes of this sensitivity analysis, a range of possible levels of federal support were examined, including 10%, 20%, 30%, 40% and 50% of the capital startup costs of NCW Options 1-5.

18.2.4 Value of Infrastructure Redundancy for Regional Water Authority

The regional water authority may become interested in the value of a redundant infrastructure in the form of a new pipeline from Oswego to Syracuse that could be derived from the construction of NCW Option 1. For the purposes of this sensitivity analysis, a range of possible levels of local support were examined, including 25% and 50% of the capital startup costs of NCW Option 1.

18.3 Results of Sensitivity Analysis

18.3.1 Assumptions

The purpose of the sensitivity analysis is to demonstrate the effect of various factors on project cost. As noted earlier in Sections 15 and 16, there are different ways to quantify cost, e.g., total project cost, operations and maintenance cost per ton of cooling delivered, etc. In this analysis, the following conditions were used as the basis of cost calculations:

- mechanical and naturally chilled water systems were assumed to deliver 24.5 million tons of cooling per year, and
- cost comparisons are based on $per ton of cooling delivered.

Cost comparisons are either on a total project cost basis or on the basis of O&M costs depending on the particular analysis. It must be remembered that total cost comparisons among the NCW options are appropriate, but total cost comparisons between NCW alternatives and mechanical chillers are for illustrative purposes as the NCW costs include all project components (intake, pipelines, buildings, etc.) while the cost for mechanical chillers includes only the costs of replacing the chillers themselves

18.3.2 Unit Cost of Electricity

The operating costs of a NCW system and existing mechanical chillers will vary depending on the unit cost of electricity. For example, the operating costs of a NCW Option 1 system as compared to existing mechanical chillers is summarized in Table 18-2.

Table 18-2.Sensitivity of Delivered Cooling Cost to Electrical Cost - Option 1

	Naturally Chilled Water Option 1			Mechanical Chillers		
Electricity Costs (per kWh)	**Cost of Electricity**	**Maintenance /Staffing Costs**	**O&M Cost per Ton Delivered**	**Cost of Electricity**	**Maintenance /Staffing Costs**	**O&M Cost per Ton Delivered**
$0.12	$1,300,000	$2,600,000	$0.16	$2,100,000	$6,700,000	$0.36
$0.24	$2,600,000	$2,600,000	$0.21	$4,200,000	$6,700,000	$0.44
$0.36	$3,900,000	$2,600,000	$0.27	$6,300,000	$6,700,000	$0.53
$0.48	$5,200,000	$2,600,000	$0.32	$8,400,000	$6,700,000	$0.62

Notes: 1. All cost estimates in 2009 dollars
2. Estimates based on plant sized to deliver 24.5 million tons of cooling per year.

Using the figures of $0.12/kWh, $0.24/kWh, $0.36/kWh, and $0.48/kWh, the effect of increasing unit costs of electricity on the overall operating costs of a NCW system and mechanical chiller systems was calculated and is presented in Table 18-3.

Table 18-3.Range of Unit Costs to Chilled Water Customers as Function of Cost of Electricity

Cost of Electricity	Estimates	Option 1	Option 2	Option 3	Option 4	Option 5
Costs common to all analyses	**Opinion of Construction Cost**	$250,000,000	$190,000,000	$170,000,000	$125,000,000	$145,000,000
	30 Year Amortized Cost	$12,750,000	$9,6900,000	$8,670,000	$6,375,000	$7,395,000
	Annual staffing.maintenance costs	$2,600,000	$2,000,000	$2,000,000	$2,000,000	$2,300,000
	Water purchased by City from MWB	-	-	-	-	$2,000,000

Note: See Section 11 for description of Options 1 - 5 and Sections 13 and 14 for description of costs.

Table 18-3.Range of Unit Costs to Chilled Water Customers as Function of Cost of Electricity (Continued)

Cost of Electricity	Estimates	Option 1	Option 2	Option 3	Option 4	Option 5
$0.12 per kWh	Annual electric costs	$1,400,000	$1,140,000	$1,140,000	$640,000	$640,000
	Annual O&M Costs	**$4,000,000**	**$3,140,000**	**$3,140,000**	**$2,640,000**	**$4,940,000**
	Total Annual Costs (Capital and O&M)	**$16,750,000**	**$12,830,000**	**$11,810,000**	**$9,015,000**	**$12,335,000**
	Cooling delivered (million tons)	24.5	24.5	24.5	24.5	24.5
	O&M cost per ton of cooling delivered	$0.16	$0.13	$0.13	$0.11	$0.20
	Total unit cost (capital and O&M) per ton of cooling delivered	$0.68	$0.52	$0.48	$0.37	$0.50
	Current actual unit cost for mechanical chilling at SU chilled water plant ($/ton)	$0.19	$0.19	$0.19	$0.19	$0.19
$0.24 per kWh	Annual electric costs	$2,800,000	$2,280,000	$2,280,000	$1,280,000	$1,280,000
	Annual O&M Costs	**$5,400,000**	**$4,280,000**	**$4,280,000**	**$3,280,000**	**$5,580,000**
	Total Annual Costs (Capital and O&M)	**$18,150,000**	**$13,970,000**	**$12,950,000**	**$9,655,000**	**$12,975,000**
	Cooling delivered (million tons)	24.5	24.5	24.5	24.5	24.5
	O&M cost per ton of cooling delivered	$0.22	$0.17	$0.17	$0.13	$0.23
	Total unit cost (capital and O&M) per ton of cooling delivered	$0.74	$0.57	$0.53	$0.39	$0.53
	Projected unit cost for mechanical chilling at SU chilled water plant ($/ton)	$0.22	$0.22	$0.22	$0.22	$0.22

Note: See Section 11 for description of Options 1 - 5 and Sections 13 and 14 for description of costs.

Table 18-3. Range of Unit Costs to Chilled Water Customers as Function of Cost of Electricity (Continued)

Cost of Electricity	Estimates	Option 1	Option 2	Option 3	Option 4	Option 5
$0.36 per kWh	Annual electric costs	$4,200,000	$3,420,000	$3,420,000	$1,920,000	$1,920,000
	Annual O&M Costs	**$6,800,000**	**$5,420,000**	**$5,420,000**	**$3,920,000**	**$6,220,000**
	Total Annual Costs (Capital and O&M)	**$19,550,000**	**$15,110,000**	**$14,090,000**	**$10,295,000**	**$13,615,000**
	Cooling delivered (million tons)	24.5	24.5	24.5	24.5	24.5
	O&M cost per ton of cooling delivered	$0.28	$0.22	$0.22	$0.16	$0.25
	Total unit cost (capital and O&M) per ton of cooling delivered	$0.80	$0.62	$0.58	$0.41	$0.55
	Projected unit cost for mechanical chilling at SU chilled water plant ($/ton)	$0.28	$0.28	$0.28	$0.28	$0.28
$0.48 per kWh	Annual electric costs	$5,600,000	$4,560,000	$4,560,000	$2,560,000	$2,560,000
	Annual O&M Costs	**$8,200,000**	**$6,560,000**	**$6,560,000**	**$4,560,000**	**$6,860,000**
	Total Annual Costs (Capital and O&M)	**$20,200,000**	**$16,560,000**	**$15,560,000**	**$10,560,000**	**$13,860,000**
	Cooling delivered (million tons)	24.5	24.5	24.5	24.5	24.5
	O&M cost per ton of cooling delivered	**$0.33**	**$0.27**	**$0.27**	**$0.19**	**$0.28**
	Total unit cost (capital and O&M) per ton of cooling delivered	$0.82	$0.68	$0.64	$0.43	$0.57
	Projected unit cost for mechanical chilling at SU chilled water plant ($/ton)	$0.30	$0.30	$0.30	$0.30	$0.30

Note: See Section 11 for description of Options 1 - 5 and Sections 13 and 14 for description of costs.

Table 18-3.Range of Unit Costs to Chilled Water Customers as Function of Cost of Electricity (Continued)

Cost of Electricity	Estimates	Option 1	Option 2	Option 3	Option 4	Option 5
$0.60 per kWh	Annual electric costs	$7,000,000	$5,700,000	$5,700,000	$3,200,000	$3,200,000
	Annual O&M Costs	**$9,600,000**	**$7,700,000**	**$7,700,000**	**$5,200,000**	**$7,500,000**
	Total Annual Costs (Capital and O&M)	**$21,600,000**	**$17,700,000**	**$16,700,000**	**$11,200,000**	**$14,500,000**
	Cooling delivered (million tons)	24.5	24.5	24.5	24.5	24.5
	O&M cost per ton of cooling delivered	**$0.39**	**$0.31**	**$0.31**	**$0.21**	**$0.31**
	Total unit cost (capital and O&M) per ton of cooling delivered	**$0.88**	**$0.72**	**$0.68**	**$0.46**	**$0.59**
	Projected unit cost for mechanical chilling at SU chilled water plant ($/ton)	$0.38	$0.38	$0.38	$0.38	$0.38
Note: See Section 11 for description of Options 1 - 5 and Sections 13 and 14 for description of costs.						

18.3.3 Value of Emissions Reductions

The value of emissions reductions at the present time are low because of the policy framework that exists to support the market in carbon credits and/or certificates, currently around $3/metric ton of CO_2 as of the March 2010 Regional Greenhouse Gas Initiative auction. However, present discussion in the U.S. Congress around climate legislation and the establishment of a carbon cap or carbon tax have centered on a starting price of around $21/metric ton. This price would increase each year at a rate to be determined by legislation, but several proposals have pegged the rate of increase at just under2% under certain “low-risk” assumptions and as high as 4.8% under “high-risk” assumptions. At a 1.985% rate of increase, the price of carbon would rise to approximately $60/ton in 2065 (that level would be reached by 2033 under the “high-risk” rate of increase). For the purposes of this sensitivity analysis, the estimated income from marketing of carbon credits was derived from a price of $21/metric ton and $60/metric ton. The results are presented in Table 18-4.

Table 18-4. Value of Avoided Greenhouse Gas Emissions as Function of Price of Carbon Credits

Price of CER or Carbon Tax		Option 1	Option 2	Option 3	Option 4	Option 5
$21 per metric ton	Electricity Usage Displaced by NCW System (kWh) - 100% utilization	14,410,722	18,510,722	18,510,722	26,910,722	26,910,722
	CO_2 Avoided (tons)	5,015	6,442	6,442	9,365	9,365
	SOx Avoided (tons)	20.9	26.86	26.86	39.05	39.05
	NOx Avoided (tons)	5.6	7.43	7.43	10.8	10.8
	Dollar Value of CO2 emission	$105,315	$135,282	$135,282	$196,700	$196,700
$21 per metric ton	Electricity Usage Displaced by NCW System (kWh) - 50% utilization	(4,394,639)	(294,639)	(294,639)	8,105,361	8,105,361
	CO_2 Avoided (tons)				2,820	2,820
	SOx Avoided (tons)				11.8	11.8
	NOx Avoided (tons)				3.25	3.25
	Dollar Value of CO2 emission				$59,240	$59,240
$60 per metric ton	Electricity Usage Displaced by NCW System (kWh) - 100% utilization	14,410,722	18,510,722	18,510,722	26,910,722	26,910,722
	CO_2 Avoided (tons)	5,015	6,442	6,442	9,365	9,365
	SOx Avoided (tons)	20.9	26.86	26.86	39.05	39.05
	NOx Avoided (tons)	5.6	7.43	7.43	10.8	10.8
	Dollar Value of CO2 emission	$300,900	$386,520	$386,520	$561,900	$561,900
$60 per metric ton	Electricity Usage Displaced by NCW System (kWh) - 50% utilization	(4,394,639)	(294,639)	(294,639)	8,105,361	8,105,361
	CO_2 Avoided (tons)				2,820	2,820
	SOx Avoided (tons)				11.8	11.8
	NOx Avoided (tons)				3.25	3.25
	Dollar Value of CO2 emission				$169,200	$169,200

As the information presented in the table shows, the value of carbon emissions reductions, even with the assumption of a price of $60/metric ton, yields only a modest level of income to offset the operating costs of NCW Options 4 and 5 at the expected 50% utilization rate.

18.4 Value of Multiple Factors - Unit Cost of Electricity, Value of Emissions Reductions, Federal Grants or Tax Incentives

It is often beneficial to examine the impact of multiple factors simultaneously when considering the sensitivity of a project's overall costs. The following table illustrates the effect of various assumptions regarding the unit cost of electricity and federal grants or tax incentives. The values presented are the total project costs expressed as $ per ton of cooling delivered for the five Naturally Chilled Water options.

Table 18-5. Naturally Chilled Water Total Project Unit Cost ($/Ton of Cooling Delivered) as a Function of Federal Grants and Cost of Electricity.

Federal Grant - Per Cent of Capital Cost	Cost of Electricity ($ per kWh)	Option 1	Option 2	Option 3	Option 4	Option 5
10%	$0.12	$0.63	$0.48	$0.45	$0.34	$0.47
	$0.24	$0.69	$0.53	$0.49	$0.37	$0.50
	$0.36	$0.75	$0.58	$0.54	$0.39	$0.52
	$0.48	$0.80	$0.62	$0.59	$0.42	$0.55
20%	$0.12	$0.58	$0.44	$0.41	$0.31	$0.43
	$0.24	$0.64	$0.49	$0.46	$0.34	$0.46
	$0.36	$0.69	$0.54	$0.50	$0.37	$0.48
	$0.48	$0.75	$0.58	$0.55	$0.39	$0.52
30%	$0.12	$0.53	$0.41	$0.38	$0.29	$0.40
	$0.24	$0.58	$0.45	$0.42	$0.32	$0.43
	$0.36	$0.64	$0.50	$0.47	$0.34	$0.46
	$0.48	$0.70	$0.54	$0.52	$0.37	$0.49
40%	$0.12	$0.48	$0.37	$0.34	$0.26	$0.38
	$0.24	$0.53	$0.41	$0.39	$0.29	$0.41
	$0.36	$0.59	$0.46	$0.43	$0.31	$0.46
	$0.48	$0.65	$0.51	$0.48	$0.34	$0.46
50%	$0.12	$0.42	$0.33	$0.31	$0.24	$0.33
	$0.24	$0.48	$0.37	$0.35	$0.36	$0.38
	$0.36	$0.54	$0.42	$0.40	$0.29	$0.40
	$0.48	$0.59	$0.47	$0.44	$0.31	$0.43

Notes: 1. All comparisons based on carbon priced at $21 per metric ton.

As might be reasonably expected, at a 50% level of federal support for capital startup costs, a wide range of NCW Options become cost competitive or achieve near parity in cost terms with existing mechanical chillers.

18.4.1 The Value of Infrastructure Redundancy for Regional Water Authority

The value of infrastructure redundancy for the regional water authority was examined, with assumed local contribution rates at 25% and 50% of the capital startup costs for NCW Option 1. Under these conditions, Option 1 becomes cost advantageous or near-competitive with existing mechanical chillers in a variety of alternative scenarios that are illustrated in Table 18-6.

It must be recognized that the project costs shown for mechanical chillers represent the cost of replacing the chillers and does not include the amortized cost of pipelines, buildings, etc. The costs shown for Option 1 include all capital costs - pipelines, buildings, pump stations, etc.

All calculations in Table 18-6 are based on a carbon unit cost of $21 per metric ton.

Table 18-6.Projected Comparison of Naturally Chilled Water Unit Cost of Cooling to Mechanical Chillers as a Function of Federal and Local Grants and Cost of Electricity for Option 1

Federal and Local Grant	Cost of Electricity ($per kWh)	Option 1	Mechanical Chillers
10% Federal and 25% Local	$0.12	$0.50	$0.21
	$0.24	$0.56	$0.24
	$0.36	$0.62	$0.28
	$0.48	$0.67	$0.33
10% Federal and 50% Local	$0.12	$0.37	$0.21
	$0.24	$0.43	$0.24
	$0.36	$0.49	$0.28
	$0.48	$0.54	$0.33
20% Federal and 25% Local	$0.12	$0.45	$0.21
	$0.24	$0.51	$0.24
	$0.36	$0.56	$0.28
	$0.48	$0.62	$0.33

Table 18-6.Projected Comparison of Naturally Chilled Water Unit Cost of Cooling to Mechanical Chillers as a Function of Federal and Local Grants and Cost of Electricity for Option 1

Federal and Local Grant	Cost of Electricity ($per kWh)	Option 1	Mechanical Chillers
20% Federal and 50% Local	$0.12	$0.32	$0.21
	$0.24	$0.38	$0.24
	$0.36	$0.43	$0.28
	$0.48	$0.49	$0.33
30% Federal and 25% Local	$0.12	$0.40	$0.21
	$0.24	$0.45	$0.24
	$0.36	$0.51	$0.28
	$0.48	$0.57	$0.33
30% Federal and 50% Local	$0.12	$0.27	$0.21
	$0.24	$0.32	$0.24
	$0.36	$0.38	$0.28
	$0.48	$0.44	$0.33
40% Federal and 25% Local	$0.12	$0.35	$0.21
	$0.24	$0.40	$0.24
	$0.36	$0.46	$0.28
	$0.48	$0.52	$0.33
40% Federal and 50% Local	$0.12	$0.22	$0.21
	$0.24	$0.27	$0.24
	$0.36	$0.33	$0.28
	$0.48	$0.39	$0.33
50% Federal and 25% Local	$0.12	$0.29	$0.21
	$0.24	$0.35	$0.24
	$0.36	$0.41	$0.28
	$0.48	$0.46	$0.33
50% Federal and 50% Local	$0.12	$0.16	$0.21
	$0.24	$0.22	$0.24
	$0.36	$0.28	$0.28
	$0.48	$0.33	$0.33

18.5 Conclusion

Sensitivity analysis indicates that the cost competitiveness of NCW Options 1-5 are affected by federal grants or tax credits or the local financial support of the regional water authority, moderately effected by fluctuations in unit costs of electricity, and much less sensitive to the value of greenhouse gas emissions reductions that might yield income from the marketing of carbon credits or certificates. Option 4 is competitive under a wide range of scenarios, with Option 5 competitive under a more narrow range of scenarios. Options 2 and 3 become competitive with the assumption of receiving federal grants or tax credits to support 50% of the capital startup costs. Option 1 becomes competitive under certain assumptions, specifically federal support in the range of 40-50% of capital startup costs combined with local support at 25-50% of capital startup costs.

18.6 Literature Cited

The New York State Energy Research and Development Authority. 2010. Patterns and Trends: New York State Energy Profiles, 1994-2008. Albany, NY.

U.S. Environmental Protection Agency. Emissions & Generation Resource Integrated Database. Available at: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html. Accessed on June 5, 2010.

19.0 Potential Ecological Effects: Source Waters

19.1 Section Introduction

In this section, we address the potential environmental impacts with respect to the source water bodies of a naturally chilled water system. The information presented here is for consideration at the screening level. If a chilled water intake were to be implemented a full scale environmental impact assessment should be conducted using detailed hydrothermal models and biological sampling protocols. The thought process used to assess potential impacts is outline in Table 19-1.

Table 19-1.Organization of Information

Category	Nature of Impact	Data Needs from Engineering Design Team	Assessment Tools to Estimate Extent of Environmental Effects	
			Screening Level	Detailed
Biological	Entrainment (organisms drawn into water intake)	Intake design, velocity at face, screening or other mitigating measures	Literature review: organisms and life stages presumed present, evaluate size and swimming speed, compare with area influenced by intake, evaluate behavioral responses to any proposed mitigating measures	Design and implement sampling program in vicinity of intake
	Impingement (organisms trapped on intake screens)			
	Transfer organisms from source water to receiving water	Provisions for disinfection		

Table 19-1.Organization of Information (Continued)

Category	Nature of Impact	Data Needs from Engineering Design Team	Assessment Tools to Estimate Extent of Environmental Effects	
			Screening Level	Detailed
Physical	Alter heat budget of source water	Intake depth (ensure consistent water temperature) and intake volume, annual and during stratified period-design maximum	Water column temperature profiles Estimate percent of hypolimnion to be withdrawn	Hydrothermal model: estimate depth strata affected by seiche action
	Sediment disturbance	Intake elevation, orientation, velocity of intake	Sediment texture	Hydrodynamic/ sediment transport model
Chemical	Biofouling preventative measures	Plans for disinfection: dosage, duration and frequency	Compare target concentrations of disinfection chemicals at intake to ambient water quality standards	Dilution/ mixing zone models

19.2 Fish impingement and entrainment issues due to water withdrawal

The depth of the proposed intake pipes in Lakes Ontario and Skaneateles are approximately 76 and 41 meters, respectively (250 and 135 feet) (see Section 13). A list was created of fish and invertebrate species whose habitat or spawning behaviors overlap with the intake end-of-pipe. Table 12-3 includes the status in the Northeast (i.e. non-listed, special concern, threatened, or endangered), the adult habitat and spawning requirements, presence in Lake Ontario or Skaneateles Lake, and the life stage (egg, juvenile, adult) present at the location of the proposed intake (see Table 12-3, pages 12-6 and 12-7).

Impingement and entrainment of organisms is of primary concern when considering ecological impacts of a cold-water intake. Impingement occurs when aquatic organisms are trapped against end-of-pipe screens by the force of the water passing through the intake pipe. Entrainment is the passage, and subsequent loss, of fish or other organisms into an intake pipe. Many organisms can be found at the potential intake location in both Skaneateles Lake and Lakes Ontario. Of these organisms there are several that may be susceptible to either impingement or entrainment because of their small size, slow swim speed, or persistence at the intake location during susceptible stages (egg, larvae or juvenile) of their respective life history. Consideration should be given to these organisms to prevent any significant effect at the population level.

It is unlikely that impingement and entrainment from a chilled water intake of moderate capacity would have a direct effect on the adult form of most species. Swim speeds that are necessary for a fish to either catch prey or avoid predators should be sufficient to avoid a through screen velocity of up to 15 cm/s (.5 ft/s). However, there are many interactions between piscivores (fish eating fish), planktivores (plankton eating fish), zooplankton, phytoplankton, and benthic macroinvertebrates that make up a food web. Changes to the population of a lower trophic level could have significant effects on sport and commercial fisheries. This section reviews the species listed in Table 19-2 with respect to their significance to the food web and to commercial fisheries, and describes the potential for adverse impacts, both direct and indirect, of a deep water intake. Significant invertebrate species are discussed in the next section.

Table 19-2. Fish and Invertebrate Species Habitats That Overlap with the Intake End-of-Pipe

Common Name	Scientific Name	Status in North-east	Adult Habitat	Spawning Habitat	Present in Lake(s)	Life Stage in Area of Intake
Alewife	*Alosa pseudoharengus*	Non-Listed	Lakes, pelagic to 100 m	Sand and gravel, shallow water	Ontario and Skaneateles	Adult
Burbot	*Lota lota*	Non-Listed	Cold, deep water of large lakes and rivers	Sandy bottom, deep water, lakes and rivers, eggs scattered and dem-ersal	Ontario	Adult
Cisco	*Coregonus artedi*	Non-Listed	Cool lakes, below the thermocline (deep), toler-ant of turbidity	Shallow water in cold lakes, broadcast spawner in open water or near substrate	Ontario and Skaneateles	Adult and juvenile
Deepwater sculpin	*Myoxocephalus thompsonii*	Endan-gered (NY)	Deep water, large lakes, from 70-100 m	Deep water; nest builder	Ontario	All life stages
Lake trout	*Salvelinus namaycush*	Non-Listed	Cold, well-oxygenated, deep water of lakes	At or near rocky bottom of deep water lakes or open water offshore; broadcast spawners	Ontario and Skaneateles	All life stages
Lake white-fish	*Coregonus clupeaformis*	Non-Listed	Cold water in lakes; below the thermocline in summer	Shallow water nearshore, rocky or sandy bottom	Ontario and Skaneateles	Adult and juvenile
Longnose sucker	*Catostomus catostomus*	Non-Listed	Cool, clear, deep lakes; usually shallow water	Gravel bottom of fast-flowing streams; broad-cast spawner	Ontario and Skaneateles	Adult
Ninespine stickleback	*Pungitius pungitius*	Non-Listed	Cool, quiet waters; occurs up to 110 m	Nearshore and shallow waters; nest builder in rocky or muddy areas	Ontario	Adult and juvenile

Table 19-2. Fish and Invertebrate Species Habitats That Overlap with the Intake End-of-Pipe (Continued)

Common Name	Scientific Name	Status in Northeast	Adult Habitat	Spawning Habitat	Present in Lake(s)	Life Stage in Area of Intake
Round whitefish	*Prosopium cylindraceum*	Endangered (NY)	Deep, cold, clear lakes; opportunistic bottom feeder but usually ventures no deeper than 50 m	Gravel bottom, shallow shoals or mouths of stream; broadcast spawner	Ontario	Adult
Sea lamprey	*Petromyzon marinus*	Non-Listed	Lakes, cold deep water below thermocline	Gravel bottom in streams and rivers; anadromous	Ontario	Adult
Slimy sculpin	*Cottus cognatus*	Non-Listed	Deep oligotrophic lakes and cold headwater streams	Streams under rocks or logs; deep water in lakes; nest builder	Ontario and Skaneateles	All life stages
Bloody red shrimp	*Hemimysis anomala*	Non-Listed	Found to 50 m on hard bottom; can survive warm or cold temperatures	Mating in spring; benthic; eggs brooded	Ontario	All life stages
Opossum shrimp	*Mysis relicta*	Non-Listed	Deep, cold, oligotrophic and mesotrophic lakes, summer in hypolimnion	Eggs released December to August to the water column	Ontario and Skaneateles	All life stages

1 Alewife (*Alosa pseudoharengus)*: Alewife is often considered a nuisance species in the Great Lakes because of massive die offs and subsequent accumulation on the shorelines. These fish can be very abundant and can alter the food web by competing with other planktivores (Hubbs and Lagler 2004). However, in lakes where alewife are established they are an important forage item for many species of sport and commercial fish (Becker 1983 Hubbs and Lagler 2004). Significant reductions in alewife biomass could significantly alter food web interactions. Adult alewife are pelagic and persist below the thermocline up to 100 meters (330 feet) (Werner 2004 and Becker 1983). Adults are strong swimmers. This is demonstrated by their ability to swim up fast-flowing rivers to spawn. Spawning in lakes occurs in shallow water and juveniles then migrate offshore. A deep, chilled-water intake should not have a significant impact on alewife as long as an intake screen and minimal approach velocities are included in the design.

2 Cisco (*Coregonus artedi*): While more important historically, cisco are still the target of a commercial fishery in the Great Lakes (Werner 2004). Adults habituate deep pelagic waters well below the thermocline and move inshore to spawn in shallow water. Adult cisco are large enough (up to 40cm (1.3 ft)) that impingement would be unlikely and eggs and juveniles are generally associated with inshore shallow waters (Hubbs and Lagler 2004). Any adverse impacts on cisco are unlikely if measures to mitigate impingement and entrainment are included in the design of the intake. However, like the alewife, cisco are planktivorous and effects to the forage base should be considered.

3 Deepwater sculpin (*Myoxocephalus thompsonii*): Deepwater sculpin are an endangered species in New York. They were once presumed to be extirpated but now are appearing again in trawl catches in Lake Ontario (Lantry et al. 2007). This species requires special consideration in the Lake Ontario intake option. Its small size (adult only reach 13cm (5 in.) in length), and persistence of all life stages at the intake depth could have deleterious effects on this rare fish if care is not taken to minimize impact. Exacerbating potential impacts of a cold water intake is the of tendency deepwater sculpin to concentrate and spawn near structure. A deepwater intake pipe could serve as an attractor to these fish. The susceptibility of this fish highlights the important of adherence to Clean Water Act Guidelines and the recommended approach velocities and intake specifications outlined in Task 5.

4 Ninespine stickleback (*Pungitius pungitius*): The ninespine stickleback is another species of concern because of its small size (average length 56mm (2.2 in.) (Becker 1983)) and location around the potential intake

pipe. They can often occur at great depths in large lakes. Although this species has not been documented in Skaneateles, it has been found in Canandaigua Lake, another similar Finger Lake (Werner 2004). Although not considered rare or threatened, consideration should be given to this species of fish during the construction and operation of a chilled water system.

5 Slimy sculpin (*Cottus cognatus*): Slimy sculpin have similar life history characteristics to deepwater sculpin and persist at great depths in both source water bodies. Considerations given to the deepwater sculpin would also minimize potential impacts to slimy sculpin.

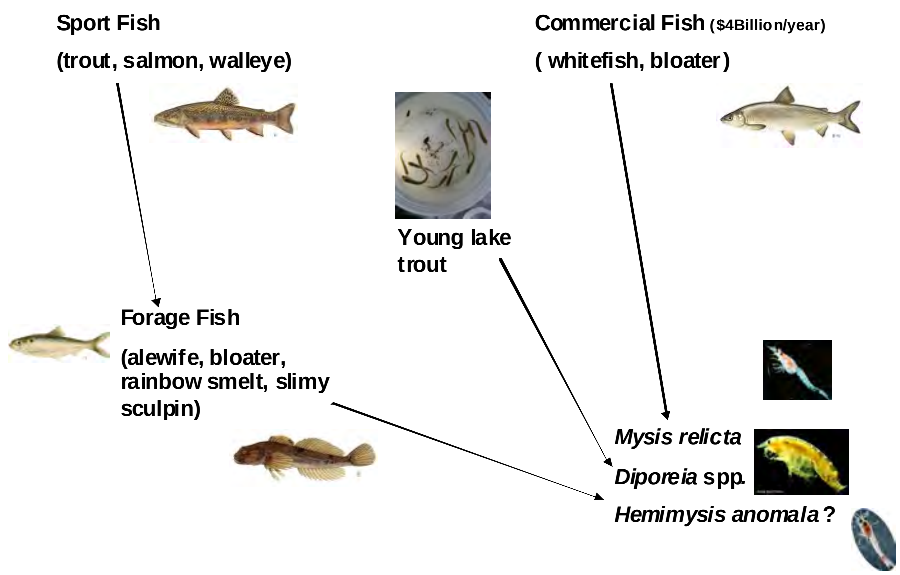
Adherence to the provisions of the Clean Water Act Section 316b in the design and construction of intake pipe should be sufficient to reduce the potential for adverse impacts on the populations of these fish species.

19.3 Impacts of impingement/entrainment on mysid shrimp, and other forage species

Two invertebrates listed in Table 19-2 are of particular importance because of their role in the food chain of the Great Lakes and Finger Lakes ecosystems. The opossum shrimp (*Mysis relicta*) and the normally dominant benthic invertebrate *Diporeia spp.* play key roles in the transfer of energy between phytoplankton and fish, and between the benthic and pelagic food webs (Figure 19-1). The schematic of the Great Lakes food web clearly shows how *Mysis relicta* and *Diporeia spp.* directly support forage fishes and indirectly sustain commercial and sport fishes in the Great Lakes. The collapse or decline of either species would have a detrimental effect on others.

Figure 19-1. The Relationships Between Great Lakes Fish and Invertebrate Species

GREAT LAKES FOOD WEB



Mysis relicta feed upon zooplankton (preferring cladocerans), detritus, phytoplankton, and insect larvae. They remain deep in the water column during the day and migrate toward the surface at twilight; this light avoidance response apparently evolved as an adaptation to avoid visual predators. Mysis influence the flow of nutrients and contaminants in aquatic systems (NOAA/GLERL(fix ref)). Cornell University reported in their Environmental Impact Statement (EIS) that *Mysis* are present at the depth of the Lake Source Cooling (LSC) intake in Cayuga Lake (Cornell 2006). A lighted intake was proposed as a mitigation measure, using the species natural avoidance of light to keep them out of the flow field induced by the intake. The light was installed, but subsequent testing of mysid entrainment documented that it was not effective. Results of biomonitoring confirm that some mysid shrimp are drawn into the LSC intake. However, the numbers are not significant to the overall population. Bioenergetic calculations indicate that the annual mass of mysid entrained is approximately equal to the mass consumed by a single lake trout.

Diporeia spp. a benthic amphipod traditionally represented 70% of the living biomass of the benthic community where they were found (NOAA/GLERL(fix ref)). A significant portion of their biomass is composed of lipids; therefore, they are a high energy food for forage species (Dermott 2001). The introduction of dreissenid mussels to the Great Lakes was followed closely by a decline in *Diporeia*. The forage fishes alewife, bloater, smelt, and sculpin feed mainly on *Diporeia*, and game fish in turn feed upon them. In Lake Michigan, *Diporeia* make up to 75% of the whitefish's diet and it has been suggested that Diporeia decline may be contributing to failing condition of whitefish (Pothoven et al. 2001). Deepwater and slimy sculpin also feed mostly on *Diporeia* and in Lake Ontario there has been a 95% decline in slimy sculpin and lake trout. While *Diporeia* are a benthic organism they do spend some time in the water column. Because of slow swim speeds, they could be subject to entrainment.

Hemimysis anomala, the “bloody red shrimp,” is a recent invader (2006) from the Black Sea, the Azov Sea, and the eastern Caspian Sea and most likely brought into the Great Lakes via ballast tanks (Marty 2008). *Hemimysis* prefers rocky areas, migrating from benthic sediments at twilight. *Hemimysis* feed upon zooplankton (preferring cladocerans), detritus, phytoplankton, and insect larvae. Like *Diporeia, Hemimysis* are considered a high energy food because of their high lipid content (Marty 2008). The role of the bloody red shrimp in the Great Lakes is yet unknown. Potential impacts include: (1) their potential population of areas devoid of native mysids (as they are tolerant of warmer temperatures), (2) the reduction of zooplankton biomass and diversity due to predation by this invader, (3) competition with other predatory zooplankton such as *Bythotrephes longimanus* and *Leptodora kindti* and, (4) alteration of the local physico-chemical environment via their fecal pellets (NOAA/GLERL(fix ref); Ricciardi 2007).

Sport fishing in the Great Lakes is valued at over $4 billion per year (NOAA GLERL(fix ref)) for lake trout, salmon (Salmonidae), walleye (*Sander vitreum*), and yellow perch (*Perca flavescens*). Forage fish such as alewife, slimy sculpin, and rainbow smelt consume *Mysis* and *Diporeia spp*. and are them consumed by Great Lakes sportfish, guaranteeing healthy sportfish populations. Populations of alewife and rainbow smelt in Lake Ontario have declined because of changes in the food web and declines in productivity in the open lake (Mills et al. 2003). In addition, the invasive round goby continues to expand in range and abundance, while increasing in importance as food for lake trout (LaMP 2008). The two most important commercial fish species in the Great Lakes, bloater and lake whitefish, consume *Mysis.* In the 1990s in Lake Michigan, *Diporeia spp.* declined so that the importance of *Mysis* as the remaining high quality food source for planktivorous fish increased (NOAA/ GLERL(fix ref)).

The introduction of dreissenid mussels and the disappearance of *Diporeia* have altered the Great Lakes fisheries; as mussels established, *Diporeia* dramatically decreased in abundance (Lozano et al. 2001). In 2003, average densities of *Diporeia* had declined to 5 individuals per m^2 from highs of between 5420 and 3011 (NOAA/GLERL(fix ref); Lozano et al. 2001). Populations of the slimy sculpin and lake whitefish collapsed in eastern Lake Ontario following the decline of *Diporeia* species, presumably because *Diporeia* was their principal food source (Owens and Dittman 2003). Owens and Dittman (2003) do not expect slimy sculpin and lake whitefish to recover unless *Diporeia* returns to earlier levels of abundance. Without *Diporeia*, the slimy sculpin is for the most part reliant on *Mysis* as a prey item and would be at risk if *Mysis* populations decline (Walsh et al. 2008). *Mysis relicta* and *Diporeia spp.* are found both in Lake Ontario and Skaneateles Lake, and *Hemimysis* is found in Lake Ontario.

In view of the facts that: (1) there are NYS aquatic species currently either in decline or endangered, (2) continuing threats of invasive species and their unknown impacts, (3) *Mysis* and *Diporeia spp*. are found in the vicinity of the intake pipe and, (4) further alterations to the aquatic food webs of the Great Lakes and Finger Lakes may have negative impacts on sport and commercial fisheries; it is important to carefully evaluate infrastructure projects that may affect elements of the aquatic communities of Lakes Ontario and Skaneateles Lake.

19.4 Impacts on the Hypolimnion of the Source Water Bodies

As part of the environmental assessment, it is important to consider potential impacts on the hypolimnion of the source water body associated with the operation of a naturally chilled water system. This section addresses the potential for changes to the size of and thermal characteristics of the hypolimnion of the source water body for the Lake Ontario and Skaneateles Lake options. Hypolimnetic volumes and calculated percentages of the hypolimnetic volume withdrawn for four withdrawal scenarios are listed in Table 7-3. Calculations were made assuming a 120-day withdrawal interval (e.g., June to September), which approximates the summer stratification period of the lakes. In addition, the summer period poses the highest demand for space cooling; customers requiring chilled water for process or manufacturing needs may be less seasonal in demand.

Withdrawals of 30 to120 MGD from the vast hypolimnion of Lake Ontario would account for just 0.001 to 0.004% of the available hypolimnetic supply. Withdrawals of this magnitude are expected to have no discernible impact on the size or temperature of the hypolimnion of Lake Ontario. In Skaneateles Lake, however, these withdrawals would consume 4.3 to 17.3% of the lake's hypolimnetic cold water resources. This would constitute a nontrivial depletion of the hypolimnion, even for the 30 MGD withdrawal rate scenario. On a qualitative basis, it is reasonable to expect a very small decrease in the thickness of the hypolimnion and an extremely modest increase in hypolimnetic temperatures, assuming that the colder, deeper layers of the hypolimnion were targeted for withdrawal. A more quantitative assessment of potential impacts would require the use of a hydrothermal/transport lake model for the lake. Upstate Freshwater Institute (UFI) has developed both one- and two-dimensional hydrothermal/transport models for Skaneateles Lake that could be used for such an evaluation.

Table 19-3.Hypolimnetic Volumes and Percentages Withdrawn from Lake Ontario and Skaneateles Lake for Four Hypothetical Withdrawal Rates

Withdrawal rates (MGD)	Percentage of hypolimnion utilized[1]	
	Lake Ontario	Skaneateles Lake
30	0.001	4.3
60	0.002	8.7
90	0.003	13.0
120	0.004	17.3
Volume of hypolimnion (gal x 10^9)	364,600	83.2

1. Volume and percentage are calculated as water withdrawn in 120 days

19.5 Impacts of quagga/zebra mussel control measures on water quality and aquatic life

19.5.1 Introduction

The accumulation, or fouling, of aquatic organisms in and around intake/outfall pipes can cause serious problems for power plants and wastewater treatment facilities. The dense colonization of organisms on intake pipes ultimately increases pipe roughness and reduces water flow through pumps. Therefore, antifouling measures are routinely employed at such facilities to prevent the successful establishment of organisms. The purpose of this section is to address: (1) fouling organisms of concern, specifically zebra and quagga mussels, (2) commonly used practices to prevent and control the fouling of intake pipes, with a focus on chlorination, (3) the effects chlorination may have on surrounding aquatic biota and water quality, and (4) to present all available, pertinent information on zebra and quagga mussels in Lake Ontario and Skaneateles Lake.

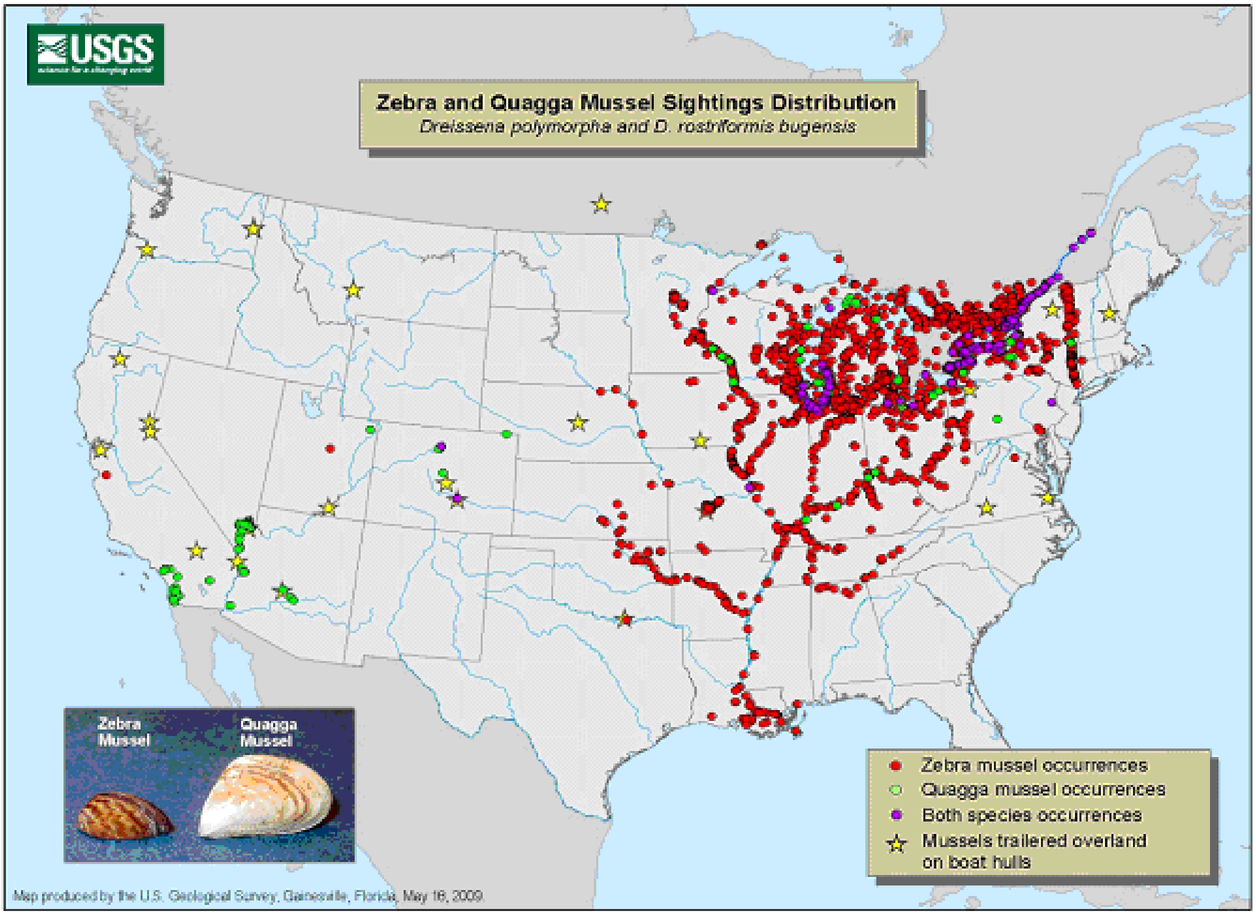
19.5.2 Organisms of concern: zebra and quagga mussels

Zebra and quagga mussels are perhaps the most problematic when considering organisms that could clog intake pipes. Both invasive species, these mussels have successfully established themselves in the Great Lakes region and have posed serious problems for lake managers.

19.5.2.a Origin and distribution in the United States

Native to the brackish Caspian and Aral Seas and the freshwater Azov and Black Seas (Spada 2000), the zebra mussel (*Dreissena polymorpha*) was the first of the two mussels to become established in North America, being first observed in Lake St. Clair in the Laurentian Great Lakes in 1986 (Turner 1990). Quagga mussels (*D. bugensis*) are an invasive relative of the zebra mussel and are indigenous to the Dneiper River drainage in Ukraine (Benson et al. 2009). Quaggas first became established in Lake Erie in 1989 (Mills et al. 1996). Today, zebra and quagga mussels are found in waters throughout the Northeast and, more recently, other parts of the United States (Figure 19-2).

Figure 19-2. Zebra and Quagga Mussel Distribution Map (USGS 2009)



19.5.3 Morphology and development

Dreissena polymorpha are bivalve mollusks with alternating light and dark bands; hence their common name, zebra mussel. Zebra mussels have a distinct ridge, or carina, allowing shells to sit upright on the ventral surface. Zebra mussel valves meet symmetrically at a ventral hinge. Though similar in appearance, the quagga mussel can often be discerned from the zebra mussel by several traits. Quagga mussels are generally rounder in shape and have a convex ventral surface, making them unable to sit upright. As opposed to zebra mussel's quagga mussel valves are asymmetrical. Color patterns in quagga mussels greatly vary; having white, cream, or black bands (Benson et al. 2009).

In the northeastern U.S., zebra and quagga mussel reproduction occurs during late spring and through the summer. The optimum water temperature for the initiation of reproduction occurs at 12°C (53°F), with peak reproduction occurring approximately mid-June, when water temperatures reach 15° to 17°C (59 to 63° F) (Cornell 2006 and Turner 1990). During this time, sperm and eggs are released into the water column from adult mussels. On average, a female zebra mussel can release 30,000 to 40,000 eggs at a time and as many as one million over a lifetime (Spada 2000). There are five stages of larval development for both the quagga and zebra mussel: (1) egg, (2) embryo, (3) veliger, (4) pediveliger, and (5) postveliger (Benson et al. 2009). The free-floating larvae are known as veligers. Though not the only mode of dispersal, this is when mussel dispersal (via water currents) largely takes place. As veligers, zebra mussels can stay in the water column for up to 10 weeks (Spada 2000). Upon shell development, zebra and quagga mussels begin to settle out of the water column and hence enter the postveliger stage. At this stage, zebra mussel veligers may range in size from 175 to 250 µm (Cornell 2006 and Spada 2000). If veligers do not attach to a hard substrate, they typically die. Similarly, dramatic fluctuations in water temperature and changes in dissolved oxygen (i.e., hypoxia) can greatly affect veliger survival. It is estimated the mortality can be as high as 99% during the postveliger, or settling, stage (Turner 1990). Settlement and subsequent attachment is most successful in areas of low water velocity. Studies suggest a water velocity less than 1.5 m/sec, or 4.9 ft/sec, is most conducive to veliger attachment (Benson et al. 2009).

Zebra mussels can grow as much as 25 mm (1 in) in their first year and another 12 mm to 25 mm in their second year (Cornell 2006). Quagga mussels have been found to grow up to 20mm (1 inch) in their first year. Environmental factors, including temperature can affect growth rates. On average, zebra mussels survive to two years (Cornell 2006). Their maximum lifespan, however, has been known to range between four and nine years (Turner et al. 1990). Quagga mussels are generally shorter-lived, with a reported maximum lifespan of five years (Britton 2007).

19.5.3.a Mussel ecology and their significance: focus on the northeast US

The addition of zebra and quagga mussels to a water body can have profound effects on the trophic structure. Their establishment depends greatly on the availability of solid substrate and an adequate food source (i.e., phytoplankton (algae)). Once established, these mussels create a "bottom-up" effect in the food chain. By consuming phytoplankton, zebra and quagga mussels reduce the zooplankton (e.g., daphnia) food source. A reduction in zooplankton can affect juvenile and planktivorous fish populations, ultimately affecting piscivorous fish populations. The reduction of phytoplankton also increases water clarity, increasing light penetration, allowing macrophytes to grow at greater depths. Such changes have been shown to subsequently alter the benthic macroinvertebrate community. Mayer et al. (2002) found benthic macroinvertebrate densities increased following the zebra mussel's invasion in Oneida Lake, NY. Similarly, Haynes et al. (2005) have found macroinvertebrate abundance and richness to increase following dreissenid invasion in Lake Ontario. The accumulation of dreissenid mussels on rocky substrate can also reduce the amount of available spawning habitat for fish that prefer such substrate (e.g., walleye and lake trout) (Turner 1990).

Studies have examined the environmental factors influencing *Dreissena* colonization and have demonstrated that quagga and zebra mussels have different habitat preferences and tolerances (Mills et al. 1993). Studies have shown zebra mussel density is positively correlated with coarser sediment (Strayer 1999; Mellina and Rasmussen 1994). Zebra mussels are typically most abundant in lake systems and prefer waters high in dissolved calcium (Strayer 1999). The optimum water temperature for zebra mussels is between 20 and 25°C (68-77°F) (Turner 1990). Mellina and Rasmussen (1994) found that calcium concentrations less than 15 mg/L hindered zebra mussel distribution in the St. Lawrence River.

Compared to zebra mussels, research suggests that quagga mussels are capable of surviving at greater depths, lower temperatures, and colonizing softer substrate (Mills et al. 1996; Mills et al. 1993). Quagga mussels have been collected at depths up to 130 m in the Great Lakes. Studies demonstrating the displacement of zebra mussels by quagga mussels in the Great Lakes and St. Lawrence River (Dittman and Walsh 2006; Ricciardi and Whoriskey 2004; Mills et al. 1993) give cause for concern as another potentially aggressive invader in the northeast.

Zebra and quagga mussels were first found in Lake Ontario in 1989 (Luckey and Richardson, 2008). Numerous studies have examined the biological and economic impacts caused following the invasion of dreissenids (Dittman and Walsh, 2006; Vanderploeg et al., 2002; Lozano et al., 2001; DePinto and Narayanan, 1997; Haynes, 1997; O'Neill Jr. 1997). Mussel data in Skaneateles Lake is limited, but studies as early as 2002 have documented the presence of zebra mussels (EcoLogic, 2004). The presence of quagga mussels in Skaneateles Lake is currently unknown.

19.5.4 Dreissenid mussels: Economic impacts

The fouling capabilities demonstrated by zebra and quagga mussels have posed considerable problems for a variety of water usages in the Great Lakes region. Such uses include recreational, shipping/navigational, water supply systems, and power plants. It was estimated that the invasion of dreissenid mussels could cost more than $5 billion between 2000 and 2010 in the Great Lakes region alone (USGS 2000; Turner 1990). O'Neill Jr. (1997) surveyed 436 water-related facility operators across the country to determine cost estimates of an array of zebra mussel impacts. He found that nuclear power plants spent the greatest amount of money with a mean cost of $786,670 per facility between 1989 and 1995. Additionally, he found that New York water treatment plants spent the greatest amount of money on "zebra mussel related activities" between the same time period, with a total cost of $7.36 million. Chemical control measures, with chlorine comprising 70% of the total, were found to be of the greatest cost to hydroelectric plants and fossil fuel electric plants, second highest for industrial facilities and third highest for water treatment plants (O'Neill Jr. 1997).

With dreissenid mussels present in both Lake Ontario and Skaneateles Lake, it is highly probable that these organisms will colonize intake pipes at one or both source water bodies. For the purpose of this project, it is therefore critical to assess the various antifouling treatment measures commonly used today and the costs associated with each.

19.5.5 Antifouling: Treatment options and their potential effects on non-target biota

Though the potential for dreissenid mussel entrainment via the intake pipes is possible, another primary concern is the fouling, or clogging, of the intake pipes in both Skaneateles Lake and Lake Ontario. Measures taken to prevent biofouling could prevent dreissenids from colonizing the pipes, but they could also help stop the successful passage of mussels into any potential receiving body, such as Onondaga Lake. It is, therefore, important to assess treatment options that are versatile in their applications, as these will most likely reduce costs and minimize potential effects, if any, on the surrounding environment. Subsequently, it is of equal importance to address the potential effects antifouling treatments could have on surrounding biota.

Various methods are commonly used to prevent and control the fouling of intake pipes, including biocides, chlorination, filtration, mechanical removal (e.g., pigging), and various pipe material and coatings (e.g., copper paint), among others. The most commonly used and effective method for mussel anti-fouling is chlorination (Jenner et al. 2009 and Rajagopal et al. 2003). However, chlorine effectiveness on dreissenid mussels decreases with temperature. The cold temperature (<6° C or 43° F) of the intake would make chlorination ineffectual. Physical removal by pigging would also likely be necessary to remove fouling organisms

Several studies have examined the use of different oxidizing chemicals to control mussel fouling. None have proven as successful as chlorine, however. Klerks et al. (2003) examined the use of chlorine, permanganate and hydrogen peroxide with iron to control zebra mussel veligers. Chlorine was found to be the most effective. Similarly, van Benschoten (2003) found chlorine to be the most effective at controlling adult zebra mussels when compared to other oxidants.

19.5.5.a Chlorination: treatment options and case studies

Chlorination, either intermittent or continuous, is the primary treatment for fouling. The choice of intermittent or continuous chlorination depends on the type of organism involved, associated costs, and subsequent volume and location of discharge. Intermittent chlorination is most effectively used for microfouling organisms (e.g., algae), while continuous chlorination, in lower doses, is best used for macrofouling organisms (e.g., mussels). Recommended concentrations of chlorine are between 0.5 and 1.0 mg/l for water treatment and 0.05 to 0.5 mg/l for antifouling intake pipes (Brungs 1973).

Because zebra mussels have the ability to close their shells and avoid unfavorable conditions for extended periods, intermittent chlorination is not effective in controlling mussel fouling. Rajagopal et al. (2003) found continuous chlorination at concentrations of 1 to 3 mg/l to induce 100% mortality after 588 hours. Using the same concentrations, intermittent chlorination at a 4-hour on and off cycle was found to be unsuccessful in controlling mussel fouling. Research has shown that the time it takes 100% mussel mortality to occur is shortened with increasing chlorine concentration. Rajagopal et al. (2002) found chlorine concentrations of 0.25 mg/l and 3 mg/l to induce 100% mortality in 1080 hours and 255 hours, respectively. Water temperature also has been found to have an effect on chlorine toxicity to zebra mussels. With a chlorine concentration of 0.5 mg/l, researchers found 95% mortality occurred after 1026 hours with a water temperature of 10°C (50° F). At the same concentration, 95% mortality occurred within 456 hours at 25°C (77° F) (Rajagopal et al. 2002).

Between 1988 and 1990, zebra mussels were found to have infested cooling water intakes at 10 power plants in the Great Lakes region. Densities of mussels varied among the power plants and were largely due to differences in water quality and temperature, dispersal rates, and available food. A power plant in western Lake Erie was found to have the highest density of zebra mussel infestation. At that plant, zebra mussels were first mechanically removed, followed by continuous low-level chlorination at a concentration of 0.5 mg/l to prevent further fouling (Kovalak et al. 2003).

19.5.5.b Effects of chlorination on aquatic life

The toxicity of chlorine to aquatic life depends on the concentration of chlorine remaining in solution, as opposed to the amount of chlorine added (Brungs 1973). The amount of ammonia in the water, pH and temperature are all variables that can affect the amount of residual chlorine, and thus toxicity in the treated water. For example, Brungs (1973) conducted a literature review, which suggested residual chlorine toxicity increased at a lower pH. With the exception of pH, most of these variables, however, do not appear to significantly affect the acute toxicity of residual chlorine.

Chlorination appears to be more lethal at lower doses than several other disinfection methods commonly used to treat wastewater. Arthur et al. (1975) found chlorination to be more lethal than ozonation and chlorination following dechlorination when tested on seven fish species and six invertebrate species. Additionally, researchers concluded that fish were more sensitive than invertebrates with LC50 values of 0.08 to 0.26 mg/l and 0.21 to 0.81 mg/l, respectively.

Chlorination has been found to affect stream index of biotic integrity (IBI) scores. Karr et al. (1985) found IBI scores to be negatively affected by effluent treated with chlorine. Following the discontinuation of chlorine, IBI scores nearly doubled from 24 to 46 after only 23 days. The index of biotic integrity is a comprehensive assessment of anthropogenic influences on watersheds, using 12 different fish community metrics. Results from this study not only suggest that a chlorinated discharge may have deleterious effects on fish communities, but it also provides one method of monitoring if such a discharge were to occur in Onondaga Lake or its tributaries.

Fox and Moyer (1975) examined the effects of chlorine on net primary productivity at a power plant in Florida that used chlorine as an antifouling agent for its intake pipes. Researchers found that water passed through the intake pipes and subsequently discharged decreased net primary production by 57%

as result of chlorination. At that power plant, chlorine was added to intake water for 15 minutes daily and residual chlorine concentrations ranged between 0.1 to 1.0 mg/l. In an effort to minimize decreases in net primary production, researchers suggest using the lowest, yet effective chlorine dosage possible when treating cooling intakes.

Hergott et al. (1978) examined chlorine uses and its effects on aquatic biota at five power plants in California. Frequency of chlorination varied among the five power plants, occurring from 4 times a day to once per week at duration of 15 to 40 minute cycles. Chlorine residuals were found in surface waters at distances of 150 to 400 m from the point of discharge. Additionally, residual chlorine concentrations were predicted to be chronically toxic to marine organisms at all of the plants and acutely toxic at one of the plants.

Studies suggest that the toxicity of residual chlorine can be minimal and even avoided if applied in low doses. The process of dechlorination can help ensure any potential toxicity to aquatic life is reduced. Ward and DeGraeve (1978) found the acute toxicity of residual chlorine was eliminated when water was dechlorinated using sulfur dioxide.

19.5.5.c Recommendations

A withdrawal from either Lake Ontario or Skaneateles Lake will need to be treated given that the receiving body is different than the source. Chlorination has proven to be a reliable and effective method for preventing and controlling intake fouling, as well as treating drinking water. The versatility of chlorination makes this mode of treatment an appropriate option for this project. Research suggests, however, that the use of chlorine to control fouling organisms can have deleterious effects on aquatic life if not applied at low doses. Studies recommend chlorine concentrations do not exceed a concentration of 0.5 mg/l at the time of application. Additionally, research suggests residual chlorine concentrations at the point of discharge should not exceed 0.01 mg/l. Dechlorination may be necessary prior to discharge to prevent adverse effects on aquatic life. Studies suggest that although chlorination is highly effective at combating macrofouling, no one method is completely effective. A combination of treatments may, therefore, be necessary. Lastly, routine monitoring of habitat and biota at the point of discharge should be employed to ensure safe levels of residual chlorine are continually maintained.

20.0 Potential Ecological Effects: Source Water Quality Issues

20.1 Section Introduction

Data from the two potential sources of naturally chilled water are reviewed. Both are sources of high quality potable water and the maintenance of their excellent water quality is a primary concern.

20.2 Physical and Chemical Characteristics of the Source Water

Lake Ontario and Skaneateles Lake are considered here as potential sources of naturally chilled water. Both lakes are oligotrophic (low productivity) and widely considered to have excellent water quality. In fact, both lakes serve as potable water supplies for the Central New York region, and Skaneateles Lake is one of the few unfiltered drinking water supplies in the country, a testament to its exceptional water quality. Both lakes thermally stratify during the summer months, thereby isolating the cold, deep waters of the hypolimnion from the well-mixed, warmer waters of the epilimnion.

Selected physical and chemical attributes of the hypolimnetic waters of Lake Ontario and Skaneateles Lake are listed in Table 20.1. Hypolimnetic temperatures are approximately 6°C (43°F) at the proposed intake depth of 41m (135 ft) in Skaneateles and 4°C (39°F) at 76m (250 ft) in Lake Ontario. Chemical features of water quality pertinent to this study are also similar in the two lakes. These are hard water systems with slightly alkaline pH values (7.5-8.0) and alkalinity concentrations of 90-100 mg CaCO3/L. Hypolimnetic concentrations of dissolved organic carbon (DOC) and total phosphorus (TP) are consistently low. The deepest layers of both layers remain oxic throughout the year, preventing hypolimnetic accumulation of phosphorus and reduced chemical species such as ammonia, ferrous iron, sulfide, and methane. Specific conductance, a measure of the water's ionic activity and content, averaged 280 μS/cm and 314 μS/cm in the hypolimnion of Skaneateles Lake and Lake Ontario, respectively. Salinity levels calculated from measurements of specific conductance were 0.14 ppt for Skaneateles Lake and 0.15 ppt for Lake Ontario. In general, water quality in the potential source waters is excellent and unlikely to result in detrimental effects to the proposed receiving waters (Onondaga Lake and its tributaries, Mud Creek and Oneida River).

Table 20-1.Physical and Chemical Attributes of the Hypolimnetic Waters of Lake Ontario and Skaneateles Lake

Attribute	Source of Chilled Water	
	Skaneateles Lake	Lake Ontario
Depth of intake	41 m (134 ft)	82-85 m (269-279 ft)
Water temperature at intake	5.4 °C (41.7°F)[1]	4.1 °C (39.4°F) [2]
pH	7.5-8.0	7.9
Total alkalinity	100 mg $CaCO_3$/L	90 mg $CaCO_3$/L
DOC	1.3-1.7 mg/L	2.0-3.0 mg/L
Redox status	oxic	oxic
Total phosphorus	5 µg/L	6 µg/L
Salinity	0.14 ppt	0.15 ppt
Specific conductance	280 µS/cm	314 µS/cm

Notes: 1. May-September mean for 2008
2. August mean for 1996-2004

20.3 Potential Construction Related Impacts to the Source Water Body

20.3.1 Disturbance to Lake Sediments.

For both Skaneateles and Ontario, off-shore segments of the CNYNCW intake pipeline will be buried within the lake bottom sediments, in order to maintain 9 ft of overlying water for recreational and navigational use. Depending on the quality of the sediments, the proposed method of construction will involve either excavating the sediments and redistributing them within the lake or removing them from the lake for upland disposal. Temporary increases in water column turbidity in the immediate area of the excavation and redistribution may occur. Best management practices will be implemented to mitigate this potential impact. Sediments will be removed from the lake using a standard clamshell or a state-of-the-art closed-bucket dredge if, after analysis of samples for hazardous chemicals, sediments are deemed contaminated. Silt curtains will be used to contain any disturbed sediments within the construction area. The impacts will be minor, temporary, and localized. No long-term impact on the aquatic biota or human users of the lake will occur.

20.3.2 Description of Impacts

If sediments are found to be contaminated, the proposed method of handling is to remove them from the lake with a closed bucket dredge and haul the sediments (after partial dewatering) to a NYSDEC-approved on-shore disposal location. If sediments are uncontaminated, they will be removed with a standard clamshell bucket and taken by barge to an in-lake disposal location. To minimize any additional disturbance of sediments, only a minimum length of the trench from the shoreline will be backfilled with clean fill after the pipelines are installed. The remainder of the trench will be allowed to fill with sediment, which will accumulate during the normal siltation process of the lake.

Sediment excavation can potentially affect the physical, chemical, and biological character of the dredging area and adjacent aquatic environment. The removal or relocation of bottom sediments causes physical alterations of the lake's bathymetry. The suspension of sediments in the water column during dredging could cause additional physical alterations. The resulting turbidity reduces light penetration and can locally increase water temperature. The temporal and spatial extent of elevated suspended solids in the water column depends on the sediment texture (particle size distribution), lake current velocity, and the efficacy of mitigating measures such as silt curtains and timing of dredging activities.

Physical impacts may have associated biological impacts as well. Sediment excavation and in-lake disposal removes habitat and destroys benthic biotic communities. Decreased light penetration temporarily alters the environment for benthic and water column photosynthetic organisms (plants and algae).

Chemical impacts result from the release of contaminants adsorbed to sediment particles or present in the pore water to the water column during dredging activities. Partitioning of organic compounds between the sediment and the water column depend on the relative affinity of each chemical for the aqueous or organic phase (commonly indexed by the atonal-water partition coefficient), the relative concentration of the chemical in the lake water and sediments, and the properties of the lake water such as pH, temperature, hardness, dissolved and particulate organic carbon and alkalinity. The amount of metals released and their biological availability also depends on the nature of the disturbance and the properties of the lake water. Each metal sulfide oxidizes at a different rate, and each solubilized metal has a unique affinity for repartitioning onto solid phase particulates in the water column and lake bottom.

Once released into the water column, the sediment chemicals may produce biological impacts, which could vary depending on the resulting concentration (after dilution and dispersion) and the temporal and spatial extent of elevated concentrations. Biological exposure and the potential for related impacts depend on the assemblage of organisms present and their vulnerability to the individual contaminants. Exposure to both dissolved and particulate contaminants in the water column is possible, depending on the feeding habits of the organisms.

Swimming and other water contact recreation will not occur within the construction zone during installation of the CNYNCW pipelines. Therefore, the potential impact on the human population is ingestion of sediment contaminants in drinking water drawn from the lake. Filtered water supplies could be affected by soluble contaminants; unfiltered water supplies could be affected by both soluble and particulate contaminants. The severity of potential adverse impacts on drinking water quality depends on the magnitude of the chemicals released, the dilution and transport mechanisms to the water intakes, and the effectiveness of the proposed best management practices in containing contaminants within the construction area.

20.3.3 Impacts of Proposed Action

The CNY NCW intake construction will result in temporary increases in turbidity. Construction and installation activities will also result in slight alterations to lake bathymetry within the dredging work area and more significant changes in the area designated for in-lake disposal, should that occur. The microbathymetric landscape could not possibly be restored to its original dimensions following pipeline installation activities. Lake bottom sediments raised during the construction activities should settle quickly following heavy disturbances. The heavier, larger particles will tend to settle out first, leaving the finest sediments on the very topmost layer. These impacts are discussed below.

20.3.4 Installation of Intake Pipeline Along the Lake Bottom

Installation of the intake pipeline along the lake bottom will require dredging in areas where the mean summer water level is less than approximately 14 ft. Dredging activities will cause a temporary increase in turbidity as sediment materials are released to the water column. Backfilled and settled sediment materials will be arranged differently than the original configuration. Heavier particles will settle first as they descend from the water column most rapidly. The finest sediments (smallest, lightest particles) from the dredged material, will settle out last, blanketing the lake bottom surface. As the finest sediments generally contain the greatest proportion of organic content, biochemical oxygen demand may increase within the silt curtained area' as a result of dredging as the biota respond to the temporarily increased food availability in the water column. Dissolved oxygen levels may drop temporarily, until the particles settle. However, the shallow lake waters are well oxygenated and dissolved oxygen depression is not likely to occur. Fish will not be affected by this confined temporary occurrence, as they tend to avoid areas of high turbidity within the water column. Lake bathymetry in the immediate area of the pipelines may exhibit microcontours that differ from the original bathymetric configuration by several inches.

In-lake drinking water supplies should not experience any impacts due to construction of the CNYNCW system. Turbidity increases during construction will be mainly limited to within the silt curtained area.

20.3.5 Disposal of Dredge Spoils

If sediments are found to be contaminated, dredge spoils will be placed in lined roll-off containers and transported to an NYSDEC-approved upland disposal site. Based on the solids content of the dredged material, solidification methods could be employed to increase the solids content to a level suitable for practicable transport and disposal, if necessary. If required, any water removed from the roll-off containers following dredging will be pumped to a temporary sediment dewatering basin constructed of hay bales and filter fabric or geotextile filter bags.

If sediments are found to be acceptable for in-lake disposal, they will be taken by barge to a designated location. With either scenario, temporary increases in the water column turbidity in the immediate area of the pipeline excavation activities or the in-lake disposal site will be the most significant sediment-related unavoidable environmental impact.

20.3.6 Chemical Impacts

Short-term chemical impacts may be associated with the construction activities, as the sediments are removed from the lake to enable installation of the intake pipeline. Laboratory analyses will be conducted to determine the concentrations of pesticides, PCBs, and semi volatile organic compounds in the sediments. Based on these analyses the toxicity to water column organisms and potential adverse impacts on drinking water quality from elevated concentrations of organic compounds will be determined.

Additional analytical testing will indicate the concentrations of heavy metals in the sediments. The potential for heavy metals to adversely impact the food web and drinking water quality of the lake depends on their concentration after dilution and transport to receptors, and their biological availability.

Concentrations of TKN in the water column may increase temporarily during construction and system startup, but will return to background as sediments settle and soluble nitrogen disperses in the lake. Ammonia concentrations may also increase temporarily, but the concentration of ammonia in the water column following initial dilution will likely fall below toxicity thresholds for aquatic organisms. No adverse impact on the aquatic biota is projected.

20.3.7 Biotic Impacts

Biotic impacts of the sediment excavation will result from the physical removal of habitat, release of chemicals in the sediment and pore water to the overlying water, and suspension of sediments and resultant turbidity. Temporary productivity increases may occur as some portion of nutrients currently held in sediments becomes available as a result of sediment disturbance during construction and startup. Motile organisms such as fish will avoid the region of elevated turbidity associated with the construction activities. The silt curtains will prevent migration of fish into the impacted area.

20.3.8 Benthic Invertebrates

Installation of the subsurface segments of the CNYNCW pipelines in the lake will temporarily disturb benthic invertebrate communities in the immediate area. One hundred percent mortality of benthic invertebrates in the dredged area and an in-lake disposal area can be assumed to occur as a result of trauma and/or burial during construction activities and the CNYNCW system startup. However, these communities should re-establish themselves quickly following disturbance based on the high population density in adjacent areas and the animals' short generation time.

20.3.9 Rooted Aquatic Plants and Algae (Macrophytes)

Macrophytes along the pipeline routes will be removed during construction. Additionally, increased turbidity and resulting sedimentation may affect the environment for macrophytes a short distance beyond the limits of construction. However, plant and algal communities should re-establish themselves quickly following construction disturbance.

20.3.10 Toxicity to Water Column Organisms

Chemicals adsorbed to sediment particles or present in the pore water may be released to the overlying water column during dredging activities. Water column organisms such as phytoplankton and zooplankton that cannot avoid the construction region could potentially be exposed to soluble or particulate contaminants that are currently held in the sediments. If sediments deemed contaminated, the proposed action to use a closed bucket dredge will minimize this potential release.

20.3.11 Impacts on Drinking Water

Based on the anticipated concentration of chemicals in the sediments and the fact that best management practices will help to contain turbidity within the excavation region, there should be no adverse impact on drinking water quality resulting from installation of the CNYNCW intake.

20.3.12 Mitigating Measures

Mitigating measures will be implemented during all phases of construction of the CNYNCW system to minimize and/or eliminate impacts to the lake bottom sediments. Construction management techniques will help to minimize the temporary impacts associated with lake bottom dredging and pipeline construction.

20.3.13 Plan for Construction in Lake

The CNYNCW pipeline in-lake construction plans will include the use of silt curtains as a measure to mitigate temporary turbidity plumes associated with dredging and in-lake disposal activities. If sediments are found to be contaminated, in order to minimize the disturbance of sediments, and thus minimize turbidity increase, we propose to utilize environmental dredging equipment (mechanical type). This will include the use of an environmental trenching bucket, which incorporates modifications from the traditional bucket that enable it to achieve a high solids to-liquid ratio and secure closure of the mouth through electronic sensors and compressible seals. The environmental trenching bucket has been demonstrated to reduce construction turbidity levels up to 90 percent, as compared to conventional trenching methods. The dredging will raise small volumes of fine sediment material into the lake's water column. These fine sediments will be confined within a silt curtain that surrounds the work area. Silt curtain material will be evaluated based on soil retention, permeability, anticlogging, survivability, durability, and application filter requirements. These design criteria will be addressed to balance the need for sediment retention with the need to withstand the lake currents.

Silt curtains will remain in place until sediments have been allowed sufficient time to settle. They will then be moved to the next segment of the pipeline construction area. Careful operation of dredging equipment will also be used as a mitigating measure to further reduce the temporary impacts associated with sediment dredging.

20.3.14 Dredge Spoils Disposal Plan.

Dredge spoils will either be transported by barge to an in-lake disposal location or be placed in lined roll-off containers and transported to a NYS-DEC-approved upland disposal site. Silt curtains will be utilized to limit (to the greatest extent possible) the turbidity increases to the construction corridor and adjacent to an in-lake disposal location. To mitigate unnecessary increases in turbidity, sediments will be removed from the lake utilizing an environmental trenching bucket. Any excess water handled during the dredging operation will be pumped to a temporary sediment dewatering basin constructed of hay bales and filter fabric or into geotextile filter bags.

20.4 Section Summary

Water quality data for the two potential sources of naturally chilled water are reviewed. In addition, potential effects of construction are described and mitigation strategies to minimize disturbances are presented.

21.0 Potential Ecological Effects: Receiving Water Quality Issues

21.1 Section Introduction

The use of naturally chilled water from large deep lakes to satisfy cooling needs is an emerging technology with a number of potential environmental benefits, including reductions in consumption of fossil fuels and production of greenhouse gases and elimination of the use of chlor-fluorocarbon refrigerants. However, there are potentially substantive water quality and aquatic ecology issues for water bodies receiving the spent cooling water from naturally chilled water systems (Matthews et al. 2002). For example, large discharges could increase flushing rates, alter constituent cycling, and modify heat budgets of receiving water bodies. The potential impacts of chilled water discharges represent interesting contrasts to common waste discharges, particularly related to the structured seasonality and dilute character of the spent cooling water (Matthews et al. 2002). In fact, the routing of spent hypolimnetic cooling water to an adjoining degraded ecosystem could offer benefits to those receiving waters. The character of the water quality issues depends in large part on the point of discharge of the spent cooling water. In the original scope of this feasibility study four potential receiving water bodies are were considered: Onondaga Lake; two tributaries to Onondaga Lake, Onondaga Creek and Harbor Brook; and Mud Creek, a tributary to Oneida River. Here we consider the potential environmental impacts associated with the discharge of spent cooling water, originating from the hypolimnion of either Skaneateles Lake or Lake Ontario, to these water bodies.

21.2 Discharge to Onondaga Lake

A detailed study was conducted as part of this project that considered limnological, water quality, and related management issues for a proposed discharge of spent cooling water from a large oligotrophic lake, Lake Ontario, to a much smaller polluted culturally eutrophic urban lake, Onondaga Lake, NY (Effler et al. 2009). The analysis draws upon multiple monitoring data sets and application of a tested model for thermal stratification/transport, dissolved oxygen (DO) in stratified layers, and epilimnetic total phosphorus (TP). The implications of different discharge flow and depth strategies for the discharge of spent cooling water were considered and evaluated with the model. The predicted impacts were considered in the context of ongoing rehabilitation programs for Onondaga Lake for domestic and industrial wastes. Key features of this analysis are summarized here, and a reprint of the full manuscript is provided in Appendix 1.

21.2.1 Background

Onondaga Lake (lat. 43° 06′54″, long. 76° 14′34″) is an alkaline, sulfate (SO_4^{2-}) rich, dimictic lake located in metropolitan Syracuse, NY. This lake has a volume of 131 x 10^6 m^3, a surface area of 12 km^2, and a maximum depth of 20 m. Onondaga Lake was oligomesotrophic before European settlement in the late 1700s (Rowell 1996), and supported a cold-water fishery into the 1890s. Increased inputs of domestic and industrial wastes that accompanied development of the watershed resulted in severe deterioration and loss of uses of the lake (Effler 1996). The commercial cold-water fishery was eliminated by the late 1800s (Tango and Ringler 1996), and the lake was closed to ice harvesting in 1901, swimming in 1940, and fishing [due to mercury (Hg) contamination] in 1970 (Effler 1996). In 1986, the fishing ban was replaced with a fish consumption advisory that is updated annually by NYS Department of Health.

Municipal waste has been discharged to the surface waters of the lake at its southern end by the Metropolitan Syracuse Wastewater Treatment Plant since the 1920s. The inflow to the lake from Metro (average of 3 $m^3 \cdot s^{-1}$) makes an extraordinary contribution for a waste water treatment plant (Rucinski et al. 2007), representing about 20% on an annual basis. Through the late 1990s Metro was responsible for 80% of the nitrogen loading to the lake (Matthews et al. 2001) and 85% of the effective (i.e., supports phytoplankton growth) phosphorus loading (Effler et al. 2002). Loads from Metro have caused profound water quality and ecological impacts in the lake (Effler 1996). Water quality and ecological implications of the Metro phosphorus load have included: (1) severe phytoplankton blooms, particularly nuisance cyanobacteria (Effler 1996); (2) low water clarity, that at times fails to meet the swimming safety standard of a Secchi transparency of 1.2 m (Perkins and Effler 1996); (3) rapid loss of DO from the hypolimnion (Matthews and Effler 2006a); (4) subsequent accumulation of reduced by-products of anaerobic metabolism, including bi-sulfide (HS-) and methane (Addess and Effler 1996); (5) depletion of DO in the upper waters during fall mixing associated with the oxidation of these by-products (Gelda and Auer 1996); and (6) exodus of fish from the lake during the fall mixing period of years of severe DO depletion (Tango and Ringler 1996). Wastewater treatment upgrades at Metro since 2004 have resulted in marked decreases in water column concentrations of ammonia and phosphorus. The problem of DO depletion during fall mixing has been ameliorated

(Matthews and Effler 2006b), primarily in response to a decrease in primary production (Effler et al. 2005).

The primary industrial polluter was a chemical manufacturing facility located along the western shore that operated over the 1884-1986 period. Saline waste from this facility had profound impacts on the physical, chemical, and biological characteristics of the lake (Effler and Matthews 2003). Residual saline waste from the site contributes to the lake's prevailing high salinity (salinity ~1 part per thousand [‰]; Effler and Matthews 2003). Moreover, approximately 75,000 kg of Hg associated with chlor-alkali manufacture were discharged from the facility (USEPA 1973), which has resulted in extensive contamination of the lake's sediments (NYSDEC 2004), water column (Bloom and Effler 1990), and biota (Effler 1996). The bottom of the lake and adjoining portions of the industrial site became a Superfund site in 1994. Internal loading of methyl mercury (CH_3Hg^+), the primary bioaccumulating toxic form of mercury (Hg), from the lake's pelagic sediments occurs annually during intervals of anoxia. Production of methyl mercury has been attributed to the anaerobic sulfate (SO_4^{2-}) reduction process in freshwater ecosystems (Benoit et al. 2001; 2003). Metro's discharge is inextricably linked to the problem of continuing internal cycling of mercury from the lake's sediments by causing anoxia (Matthews and Effler 2006a) and the subsequent operation of the sulfate reduction process (manifested as accumulations of the hydrogen sulfide ion HS^-). Recent decreases in hypolimnetic accumulations of methyl mercury have been attributed to increased availability of DO and nitrate in the hypolimnion (Todorova et al. 2009).

Summertime temperatures (T, ºC), salinities (S, ‰) and concentrations of selected constituents of water quality interest are compared for potential receiving waters of the epilimnion and hypolimnion of Onondaga Lake, the Metro effluent, and the hypolimnetic depth of Lake Ontario (Table 21-1). Hypolimnetic conditions in Skaneateles Lake are presented for comparison, though a modeling analysis was not conducted for this potential source water. The different time intervals considered for the epilimnion (summer average) and hypolimnion (late August) of Onondaga Lake are consistent with the respective water quality concerns; e.g., total phosphorus concentration of the epilimnion (TPe) for the upper waters and anoxia and mobilization of various constituents from the sediments. Wide differences in concentrations of TP, DO, and the sum of NO_3^- and NO_2^- (NO_x) develop vertically in the water column of Onondaga Lake over the summer interval (Table 21-1). Hypolimnetic conditions reflect the operation of biochemical processes involved in the stabilization of depositing organic material, which are localized at the sediment-water interface and driven by the lake's culturally eutrophic state (Effler 1996; Matthews and Effler 2006a). In particular, the electron acceptors of DO and NO_3 (dominant component of NO_x) are both depleted from the hypolimnion (Matthews and Effler 2006a; Effler and Matthews 2008). Metro, as the primary source of N and P to the lake, is enriched with respect to concentrations of these constituents in the epilimnion of Onondaga Lake (Table 21-1). The lake is more saline than the Metro effluent because of both natural and residual industrial waste inputs received via tributaries (Effler and Matthews 2003). The hypolimnetic waters of Lake Ontario and Skaneateles Lake are dilute with respect to TP, $NO_x$and S compared to the epilimnion of Onondaga Lake and Metro (Table 21-1). Further, DO levels in the hypolimnion of Lake Ontario and Skaneateles Lake are much higher than those in the hypolimnion of Onondaga Lake, which is anoxic by August (Table 21-1). Variations in N, P, and DO concentrations within hypolimnetic depths of Lake Ontario and Skaneateles Lake are minor relative to the levels that prevail in the potential receiving waters of Onondaga Lake.

Table 21-1.Comparisons of concentrations and temperatures: Onondaga Lake, Syracuse Metropolitan Wastewater Treatment Plant (Metro), Lake Ontario, and Skaneateles Lake. Modified from Effler et al. (2009).

Metric	Onondaga Lake		Metro[a]	Lake Ontario	Skaneateles Lake
	epilimnion[a]	hypolimnion[b]		hypolimnion[c]	hypolimnion[d]
T (^{o}C)	20.8	13.6	18.8	4.1	5.4
TP (μg L^{-1})	60	353	530[e]	6	5
DO (mg L^{-1})	10.2	0.0	-	12.7	11.4
NOx (mg L^{-1})	1.5	0.4	10.9	0.4	0.7
S ($^{o}/_{oo}$)	0.93	1.00	0.83	0.15	0.14

Notes: a. Summer average
b. late August, volume-weighted
c. August, depth of 82-85 m
d. May-September, depth of 40 m
e. 2004 present, 120 starting in 2006, 0.020 starting in 2012

21.2.2 Discharge scenarios

The discharge of hypolimnetic Lake Ontario water as spent cooling water offers potential water quality benefits to Onondaga Lake with respect to: (1)

dilution of inputs from the Syracuse Metropolitan Wastewater Treatment Plant (Metro), particularly phosphorus (e.g., abatement of cultural eutrophication) or (2) direct augmentation of DO and NO3- levels in stratified layers. The effective depth of entry of a cooling water discharge is critical in achieving these different potential benefits. Efforts to ameliorate the impact of Metro on cultural eutrophication would require entry of these two inputs into the same layer(s) of the lake; best achieved through mixture before a combined (Metro effluent plus spent cooling water) discharge. Eight NCW discharge scenarios are reported on here, that correspond to combinations of four cases (1-4) of discharge depth, use of a diffuser, and mixture of the NCW and Metro discharges (Table 21-2), and two levels of peak QNCW(30 and 120 MGD; i.e., two flows times four cases for eight scenarios). Two cases associated with this goal are identified, discharge of the Metro and cooling water mixture to the epilimnion (Case 1) and to the metalimnion (Case 2). The potential benefits of Case 1 rely strictly on dilution, while Case 2 may also benefit from isolation of the phosphorus-rich load from the upper productive layers. Decreases in deposition of organic material that would result from reductions in primary production would eventually (delays associated with sediment diagenesis) be accompanied by reduced levels of decomposition and associated fluxes, including oxygen demand by pelagic sediments (Matthews and Effler 2006a).

In contrast, direct augmentation of DO and NO3- resources in the metalimnion or hypolimnion would require effective entry of the NCW discharge (i.e., full integration) into those deeper lake layers. The targeted benefits of a hypolimnetic discharge without Metro (Case 3) could include abating sediment release of undesirable constituents, such as methylmercury (CH3Hg+) and phosphorus, or even the maintenance of oxygen concentrations adequate to support cold water fish. The maintenance of proximity of the cooling water discharge to the pelagic sediment-water interface, thereby preventing anoxia at this boundary, would be important to block mobilization of these constituents (Cooke et al. 1993). A metalimnetic discharge without Metro (Case 4) instead would primarily target oxygen resources, with a goal of providing a refugium for cold water fish. The potential for achieving the above benefits needs to be considered not only in the context of the buoyancy of the discharge, but also its effects on water and material budgets and the cycling of key constituents.

Table 21-2. Specification of discharge configurations considered in model evaluation

Case	Discharge Layer	Diffuser	Discharge Mix with Metro	Comments[a]
Base	-	N	N	2004 conditions, without NCW discharge, prevailing conditions
Case 1	epilimnion	Y	Y	positive- minor reduction in TPe
Case 2	metalimnion	N	Y	positive- some potential for small refugium for cold water fish, best for reduction of TPe
Case 3	hypolimnion	Y	N	negatives- promotes upward transport of sediment releases, without maintaining oxygen levels
Case 4	metalimnion	N	N	positive- best potential for modest refugium of DO and T conditions for cold water fish
Note: a. All cases and scenarios (Q_{NCW} = 30 to 120 MGD) would result in shallower epilimnion by late summer.				

21.2.3 Model Projections

None of the NCW discharge scenarios were predicted to have substantial impacts on the timing of the onset of fall turnover (i.e., duration of stratification) or the temperatures of the epilimnion and lower portions of the hypolimnion. However, noteworthy reductions in the thickness of the epilimnion are predicted for all scenarios by late summer, for the higher QNCW scenarios emphasized here. Qualitatively similar, but smaller magnitude, effects were predicted for the lower QNCW scenarios. Such an effect could increase phytoplankton concentrations within the epilimnion (Stefan et al. 1976). The predicted effects of a NCW input reflect the displacement of epilimnetic water (e.g., increased export from flushing) by the cooler waters of the discharge that would enter the underlying metalimnion.

The epilimnion discharge of the mix of the NCW and Metro discharges (Case 1) was predicted to result in a shallower epilimnion in late August compared to the base case. This reflects the failure of a diffuser to retain the relatively cool mixture of the Metro and NCW discharges completely within this generally well mixed layer. The Case 1 scenarios (maximum QNCW of either 30 or 120 MGD) would have the smallest cooling effect on the overall water column. More cool water would be integrated into metalimnetic depths for the other cases. The Case 1 scenarios would have only modest benefit, relative to the base case, in reducing TPe (3 to 9%), in part because of the failure to completely retain this input within the epilimnion.

A metalimnetic discharge of the mix of the NCW and Metro effluents (Case 2) is predicted to decrease temperatures in the metalimnion and create a modest (~1 m thick) refugium for cold water fish that does not presently exist. In addition, Case 2 is predicted to achieve the maximum benefit in reducing TPe levels (12 to 20% decrease). The greater benefits in this regard for Case 2 are associated with the higher QNCW. The Case 2 benefits cannot match those associated with increased P treatment at Metro; decreases of 50 and 60% in TPe are predicted for the mandated improvements in Metro effluent TP of 0.120 and 0.020 $mg \cdot L^{-1}$, respectively. Moreover, the relative benefit of Case 2 scenarios would decrease as the mandated reductions in TP concentration of the Metro effluent were achieved. However, the relationships between TPe and related metrics of water quality (e.g., clarity) are non-linear such that disproportionate improvements may be observed from numerically small decreases in TPe in lower concentration ranges (e.g., Chapra 1997).

A hypolimnetic discharge (Case 3) would nearly eliminate thermal (and density) gradients within the hypolimnion as a result of upward transport of the combined buoyant input and entrained ambient lake waters (Owens and Effler 1996), because this input was predicted not to be retained within the lower layers (with the use of the specified diffuser). Under such conditions, there would also be minimal resistance to diffusivity-based upward transport of constituents released from the lake's sediments (Jassby and Powell 1975). Epilimnetic TP concentrations are predicted to increase from 2 to 14% as a consequence of the upward transport of P originating in the sediments. Some benefit of increased DO levels for portions of the hypolimnion are predicted for mid-July, however, an anoxic depth interval would persist below the depth of the diffuser because of the buoyancy of the NCW discharge. Installation of a diffuser instead onto sediments is normally avoided because of concerns for sediment resuspension. Such an action would be particularly undesirable for Onondaga Lake, given the contaminated state of this lake's sediments (NYSDEC 2004).

The metalimnetic NCW discharge case without the Metro effluent (Case 4) is predicted to result in a strong temperature gradient in the metalimnion, and it would retain a gradient in the lower hypolimnion consistent with prevailing conditions. At the higher QNCW level (120 MGD) this discharge scenario offers the greatest potential to support a cold water refugium. The temperature and dissolved oxygen requirements for cold water fish would be satisfied continuously in a somewhat thicker (2 m) layer than predicted for Case 2. The lower 30 MGD version of this discharge case could not meet the specified requirements throughout the stratification period. This discharge would not provide tangible benefits with respect to decreased TP concentrations in the epilimnion; decreases of 1 to 2% are predicted.

The adopted model framework has served to quantify selected impacts of an array of NCW discharge scenarios for Onondaga Lake. Advancement of the overall NCW facility initiative at this site can be expected to be accompanied by the demand for more robust modeling analyses, with attributes that may include: (1) increases in the number of model state variables and the robustness of kinetic representations to address a wider array of water quality parameters/issues; (2) inclusion of a sediment submodel to represent the effects of diagenesis processes, including the time course of changes in sediment-water exchange in response to changes in overlying water primary production (Chapra 1997); (3) multi-dimensional transport frameworks that do not invoke horizontal uniformity, to characterize potential spatial heterogeneity; and (4) evaluation of responses to multiple years of driving conditions (e.g., Gelda et al. 2001) to establish reasonable expectations for interannual variations in impacts of discharge scenarios.

21.2.4 Management Perspectives

Urban aquatic ecosystems represent the greatest challenges for recovery and protection of associated resources because of the severity, number, and complexity of stressors. The proposal to bring the innovative NCW technology to metropolitan Syracuse to meet future cooling needs creates an interesting intersection with the ongoing efforts of this community and regulatory institutions to reclaim resources of the adjoining polluted Onondaga Lake. The much better quality of the NCW source water, the hypolimnion of Lake Ontario, relative to Onondaga Lake, particularly the lower TP and higher DO concentrations, offer the potential for benefits from such a discharge. A combination of limnological and modeling analyses was conducted here to identify and evaluate NCW discharge scenarios for Onondaga Lake, supported by a rich array of pertinent data.

The much higher salinity of Onondaga Lake relative to the proposed NCW discharge (Lake Ontario or Skaneateles Lake) plays a central role in regulating its buoyancy, thereby limiting the practical options for the depth of the discharge. In particular, a discharge to the hypolimnion, even when modified by a diffuser, would not be retained within those lower lake layers. Moreover, such a discharge would increase upward transport of constituents mobilized from sediments, including P and perhaps methylmercury. Enhanced upward transport of these constituents would be strongly at odds with the ongoing rehabilitation programs for domestic waste and the Superfund site. For these reasons, a hypolimnetic NCW discharge should not be considered a viable option. All scenarios considered would result in a shallower epilimnion by late summer. Depth intervals with DO > 5 $mg{\cdot}L^{-1}$ and T < 15 ºC were predicted to be maintained continuously within the metalimnion through summer stratification for a metalimnetic NCW discharge scenario with high at 120 MGD, representing potential, albeit modest, refugium conditions for cold water fish that presently do not exist. A metalimnetic discharge of the combined Metro effluent and NCW input would reduce TPe the most (~ 20% relative to 2004 base case) of the considered scenarios, and thereby ameliorate the lake's cultural eutrophication problems. However, the benefits from this NCW discharge strategy would be substantially less than the improvements associated with the decreases in Metro effluent TP concentrations mandated in the ongoing rehabilitation program for the lake's domestic waste problems.

21.3 Discharge to Onondaga Creek, Harbor Brook, or Mud Creek

During this feasibility analysis three water bodies in addition to Onondaga Lake emerged as potential receiving waters for an NCW discharge, including two tributaries to Onondaga Lake, Onondaga Creek and Harbor Brook; and Mud Creek, a tributary to Oneida River. A preliminary screening level analysis of potential water quality impacts on these streams is presented here. It is recommended that a more comprehensive analysis of water quality impacts be conducted if one of these alternatives receives further consideration in the future. A wide range of NCW discharge flow rates (30 to 120 MGD) is considered here, although it is likely that actual discharges to these streams would be at the lower end of this range.

Potential water quality impacts on these streams from the discharge of spent cooling water would be determined by flow rates and water quality conditions of the input. Summer average (June-August) conditions of flow, temperature, pH, and total phosphorus (TP) are presented in Table 21-3 for Onondaga Creek, Harbor Brook, Oneida River, and the possible source waters, Lake Ontario and Skaneateles Lake. No flow or water quality information was found for Mud Creek, so we will focus on the potential for impacts on Oneida River, which receives the Mud Creek flow. The temperatures listed in Table 21-3 for Lake Ontario and Skaneateles Lake are for the hypolimnetic source waters, and thus represent a lower bound on the temperature of waters discharged to the streams. It is likely that actual discharge temperatures would vary seasonally, with maximum temperatures of ~ 10°C during the June to August interval, as reported for the Cornell University NCW facility (Effler et al. 2009).

Table 21-3. Summer Average (June-August) Conditions of Flow, Temperature, pH, and Total Phosphorus (TP) for Potential Receiving Waters of a NCW Discharge. Values for the Potential Source Waters, Lake Ontario and Skaneateles Lake, Presented for Comparison.

Water Body	Flow (MGD)	Temperature (°C)	pH	TP (μg/L)
Onondaga Creek	170	18	7.7	64
Harbor Brook	14	17	7.7	76
Oneida River	2176	21	8.0	46
Lake Ontario (82-85 m)	30 - 120	4	7.9	6
Skaneateles Lake (40 m)	30 - 120	5	7.5 - 8.0	5

Compared to summertime conditions in the prospective receiving streams, the source waters of Lake Ontario and Skaneateles Lake are substantially colder and have much lower TP concentrations (Table 21-3). In addition, the source waters are oxygen-rich (Table 21-1) with dissolved oxygen concentrations at saturation levels with respect to the atmosphere. An influx of cold, well oxygenated water to these streams during the summer months could alter the composition of biotic communities and would likely be advantageous to some lotic species (e.g., salmonids). The magnitude of potential impacts would depend importantly on the volume and timing of NCW discharges. An NCW discharge on the order of 30 MGD would likely result in substantial impacts to Onondaga Creek, Harbor Brook, and Mud Creek because of the modest summertime flows in these streams. In contrast, impacts of an NCW discharge on Oneida River would likely be insignificant because of its much higher flow rate, even at the highest NCW flows considered here. The influx of colder, less saline water to Onondaga Creek and Harbor Brook could significantly alter the density of these streams and affect the depth of entry into Onondaga Lake. A modeling analysis, similar to that described above for a direct NCW discharge to Onondaga Lake (Effler et al. 2009), could be conducted to evaluate potential impacts to the lake from an NCW discharge to these streams.

21.4 The implications of the discharge quality to mercury and other key chemical constituents in the receiving water bodies

21.4.1 Introduction

The purpose of this section is to address the potential chemical changes resulting from the discharge of a variable flow of potable water to tributaries that discharge into Onondaga Lake. One concern related to the potential cooling water system is the possible effect of such discharge on remediation of Onondaga Lake in general and mercury cycling in particular.

21.4.1.a Sources of mercury to Onondaga Lake

Onondaga Lake, located adjacent to Syracuse New York, has a history of industrial and municipal contamination and has been listed as a federal Superfund site. Sediment, particularly along the southern shore poses risk to sediment-dwelling organisms while contaminant concentrations in fish pose risk to wildlife and humans who consume fish. Within the lake, mercury is a contaminant of particular concern due to its bioaccumulation into fish tissue. Its presence in the lake derives from historical discharges from two former mercury cell chloralkali plants. Based on the 2005 Record of Decision, the remedy to address contamination of the lake is currently in the design phase with implementation to begin in 2012. Currently, the most significant mercury input to the lake is from Ninemile Creek, accounting for approximately 50 percent of the total mercury input from external sources (TAMS and YEC, 2002). Mercury also enters Onondaga Lake from regional non-point sources, such as wet and dry deposition to the watershed of atmospheric mercury produced by coal-burning power plants. Ninemile Creek, along with Onondaga Creek, are the major tributaries to the lake, each accounting for approximately one-third of water flow to the lake on an annual basis. Harbor Brook, a minor tributary to the lake that accounts for approximately two percent of annual water flow, is the subject of ongoing investigation and future remediation to address contamination in its reaches as well as being a source of contamination to the lake.

21.4.1.b Mercury cycling within Onondaga Lake

Although the mercury entering Onondaga Lake is primarily inorganic (Henry et al. 1995), methylmercury is the species of concern because of its bioaccumulation and potential toxicity. Most of the methylmercury in the water column is produced within the lake via bacterial methylation of inorganic mercury under anoxic conditions, with a small component entering from tributaries and atmospheric deposition. Anoxic conditions develop seasonally in Onondaga Lake. During the summer months, the hypolimnion is anoxic and, until recent years, sulfidic starting at approximately 10 meters below the water surface. The presence of sulfide indicated active bacterial sulfate reduction, for which mercury methylation is a by-product. In recent years, the onset of stratification has occurred later, resulting in a shorter duration during which significant sulfate reduction and therefore mercury methylation occurs (Todorova et al., 2009).

21.4.2 Potential chemical effects of the addition of cooling water from Lake Ontario and Skaneateles Lake on mercury cycling and other contaminants

As proposed, the water introduced into Onondaga Lake will originate from either Lake Ontario or Skaneateles Lake. The water will be extracted, treated to potable standards at a drinking water treatment plant, and used as cooling water first and than distributed as potable water. After use, the water will be discharged into sewers and undergo treatment at the Metropolitan Syracuse Wastewater Treatment Plant (Metro). The treated wastewater effluent will be discharged to Onondaga Lake (OCDWEP 2009a). If the volume of cooling water exceeds the capacity of Metro, it will be discharged to either Onondaga Creek or Harbor Brook, two of the tributaries on the southern end of Onondaga Lake. In total, 20 percent of Onondaga Lake's annual inflow is wastewater discharge from Metro; the remainder is from several tributaries (OCDWEP 2009b).

Because the cooling water will have undergone treatment to potable standards, the water quality of this discharge will be equivalent to local drinking water. However, unlike most of the water used as drinking water, this discharge will not necessarily be channeled through wastewater treatment prior to release to the creeks. The Metropolitan Water Board (MWB) is responsible for treating raw water from Lake Ontario to potable standards for drinking; in the case of Skaneateles Lake water, the City of Syracuse Water Department provides drinking water treatment. MWB treatment of Lake Ontario water includes coagulation and filtration using six dual media filters, consisting of granular activated carbon, sand, and gravel, as well as the addition of fluoride (for teeth) and sodium hypochlorite (for disinfection) (OCWA 2008). For drinking water sourced from Skaneateles Lake, the City of Syracuse Water Department does not perform filtration, as they have been granted a waiver from the New York State Department of Health. Fluoride (for teeth) and orthophosphate (for lead and copper pipe corrosion control) are added, as well as chlorine and/or sodium hypochlorite for disinfection (OCWA 2008).

21.4.2.a Direct Effects: Addition of mercury and/or other contaminants

Neither Lake Ontario nor Skaneateles Lake are expected to directly increase the concentration of mercury in Onondaga Lake. A study of mercury concentrations in Lake Ontario showed levels of 0.14 to 1.34 ng/L total mercury in unfiltered surface waters (Amyot et al. 2000). These data are the sum of both dissolved and particulate components. However, if the water is taken from lower depths, the amount of particles present is expected to be greater (Marvin et al. 2007) and the overall mercury concentration could be higher due to the presence of suspended bottom sediments, especially in winter when the lake is more well-mixed. If the input from Lake Ontario was taken from near the bottom sediments, particulate bound mercury could be added to the surface sediments in Onondaga Lake, but this is unlikely, because for potable use this water will be filtered. Skaneateles Lake is the drinking water source for Syracuse, and has relatively low mercury concentrations.

As noted above, the water quality of the cooling water discharge to Onondaga Lake will be equivalent to local drinking water. A direct effect of such a discharge would be the addition of any chemical constituents found in the drinking water. Water quality data for the treated drinking water sourced from Lake Ontario and Skaneateles Lake is available from the Onondaga County Water Authority (OCWA 2008). Mercury was included in their 2008 analysis but was undetected by standard methods. Cooling water discharge is not expected to directly contribute mercury to Onondaga Lake.

Fluoride is added to drinking water from both Lake Ontario and Skaneateles Lake as a dental health measure, to average concentrations of 1.04 and 0.96 mg/L, respectively (OCWA 2008). No information is available on background fluoride levels present in Onondaga Lake nor in Metro wastewater discharge; however, the concentration of fluoride in municipal treated wastewater is typically approximately 1 mg/L, and natural aquatic background concentrations are about 10 to 100 times lower (Weinstein and Davison 2004; Yu et al. 2005). The water quality standard for the New York State Department of Environmental Conservation (NYSDEC) is 1.5 mg/L fluoride in surface waters such as

Onondaga Lake (NYSDEC 2009). The cooling water discharge, at approximately 1 mg/L fluoride, would therefore not be expected to result in an Onondaga Lake fluoride level in excess of the state criteria, and would likely be similar in concentration to the wastewater effluent discharged to Onondaga Lake by Metro. Ambient surface water fluoride concentrations were not reported in the Onondaga Lake Ambient Monitoring Program 2007 Annual Report (OCDWEP 2009c).

As a disinfection measure, sodium hypochlorite is added to both Lake Ontario and Skaneateles Lake drinking water, resulting in a free chlorine residual of 0.87 and 1.33 mg/L, respectively. Ambient free chlorine concentrations were not reported in the Onondaga Lake Ambient Monitoring Program 2007 Annual Report (OCDWEP 2009c). The surface water quality standard for NYSDEC is 5 µg/L total residual chlorine (NYSDEC 2009); therefore, the cooling water may require some type of dechlorination prior to discharge to Onondaga Lake, depending on the anticipated mixing of discharged water with lake water.

Drinking water typically also contains low amounts of disinfection by-products, such as trihalomethanes (THMs) and haloacetic acids (HAAs), which are produced unintentionally during water disinfection with chlorine. According to the 2008 Annual Report, drinking water from Lake Ontario contained 10.2 µg/L total THMs and 6.9 µg/L HAAs. These are below the regulatory limit for drinking water of 80 and 60 µg/L, respectively; NYSDEC does not stipulate a surface water quality standard for trihalomethanes and haloacetic acids, nor were the ambient concentrations of these constituents assessed in the Onondaga Lake Ambient Monitoring Program 2007 Annual Report (OCDWEP 2009c).

As noted previously, orthophosphate is added to drinking water sourced from Skaneateles Lake as a pipe corrosion inhibitor. While the concentration in the drinking water was not assessed in the 2008 Annual Report (OCWA 2008), the maintenance dose for this type of application is typically 0.5 - 1.5 mg/L (US EPA 2009). Phosphorus inputs to the lake are a key issue in the ongoing Onondaga Lake monitoring and rehabilitation effort, because phosphorus is the limiting nutrient for algal growth in the lake (OCDWEP 2009c). The primary point and nonpoint sources of phosphorus to the lake are Metro effluent and watershed runoff, respectively. Recent measurements at Onondaga Lake indicate that phosphorus levels are currently at about 25 µg/L (OCDWEP 2009c). The significance of the potential contribution of the cooling water discharge to phosphorus in the lake will depend upon the source water selected (orthophosphate is added to drinking water from Skaneateles Lake but not Lake Ontario) and on the volume of cooling water discharged.

Because the cooling water will be discharged to a tributary of Onondaga Lake, some natural attenuation of the concentrations of the drinking water-derived constituents may occur along the creek flow path, thereby reducing the amounts of these compounds entering the lake. Volatilization from the surface of the water may reduce the concentration of free chlorine and trihalomethanes, and certain haloacetic acids are biodegradable (Osterman 1990; Chen, Westerhoff et al. 2008). However, the extent to which these processes occur is site-specific and will depend upon the amount of mixing and the nature of the microbial community.

21.4.2.b Direct Effects: Dilution

Since the input water is expected to be cleaner and less saline than the receiving water, the ultimate effect of the discharge could be dilution of the water in Onondaga Lake. Because some of the water would be directed through Metro, only the excess beyond that amount would affect dilution in the lake. These volumes are currently unclear.

The loading of nitrogen species, including ammonia-N, nitrite-N, and nitrate-N, is an issue of concern for Onondaga Lake (OCDWEP 2009c). According to the OCWA 2008 Annual Report (OCWA 2008), nitrite was not detected in Lake Ontario or Skaneateles Lake drinking water, and nitrate is present in Lake Ontario and Skaneateles Lake drinking water at concentrations (0.35 and 0.64 mg/L, respectively) lower than in Onondaga Lake (OCDWEP 2009c), where approximately 2 mg/L was measured in 2007 (South Deep Station). The cooling water discharge would therefore represent a dilution of these constituents. Ammonia was not measured in either drinking water.

21.4.2.c Indirect effects: Methylmercury Production and Bioaccumulation

The water discharged to Onondaga Lake is expected to range from 0.5 degrees Celsius in winter to 10 degrees Celsius in the summer (Effler et al. 2009), and the water temperatures in Onondaga Lake range from approximately 4 to 25 degrees, suggesting that the effluent should consistently be colder than the receiving waters. Depending on the distance the discharge is from the lake, this temperature difference may be preserved as the tributary flows into the lake. Overall, a decrease in the temperature could result in a longer mixed period and shorter summer stratification. Because the production of methylmercury is associated with summer stratification, this could reduce the overall methylation and bioaccumulation of mercury. However, in several simulations run by Effler et al. (2009) this effect was not predicted. Also, the water in Onondaga Lake is more saline than either Lake Ontario or Skaneateles Lake, so the cold discharge may not sink immediately or stay in the hypolimnion, but find an intermediate layer where it is neutrally buoyant. This could result in a decreased epilimnetic volume (Effler et al. 2009), and possibly increased sulfate reduction and mercury methylation.

Because the concentrations of mercury at lower trophic levels are directly related to the concentrations in nearby sediment, any changes to the concentrations of mercury in the uppermost layers of the sediment are expected to affect the mercury bioaccumulation in the food web (either negatively or positively). A decrease in the time of stratification could reduce the amount of mercury methylated, but may also provide more time for animals to come in contact with contaminated sediment.

21.4.2.d Indirect Effects: Resuspension of Tributary Sediments

Both Onondaga Creek and Harbor Brook have flows which vary seasonally and with storm events. As flows increase, the amount of suspended solids increases as well. Because mercury and methylmercury tend to associate with particles, increased particle transport due to increased flow could lead to higher mercury loading to Onondaga Lake from the tributaries. This is of particular concern in Harbor Brook, which is currently contaminated with mercury. However, this area is slated to undergo remediation, which would likely be completed prior to the discharge of cooling water.

21.4.3 Other considerations

Recent measurements of Onondaga Lake have shown that with increased nitrate concentrations, depletion of oxygen in the hypolimnion is delayed, and overall mercury methylation is decreased (Todorova et al. 2009). This is thought to be the result of a shift of bacterial metabolism with the presence of nitrate as an additional electron acceptor delaying the onset of sulfate reduction, which is known to be associated with bacterial mercury methylation. The effect is similar to aerating a lake to prevent sulfate reduction, but has the potential to be more effective, since nitrate is more soluble than oxygen. Additionally, the presence of nitrate at depth would not encourage the bioturbation of sediments, potentially exposing previously buried mercury. The cooling water discharge to Onondaga Lake could be used to manipulate this system. By supplementing the cooling water discharge with nitrate, it could be possible to use the cooling water system as a way to bioremediate the lake by altering the redox conditions and decrease rates of mercury methylation with a cost savings since the infrastructure would already be in place. However, the model predictions by Effler et al. (2009) suggest that there could be difficulty in retaining this water at the depths where it could be most useful. Additionally, with the complication of using the cooling water as a potable water source, any additions would need to meet drinking water regulations and the variable nature of the output to the creek would make the nitrate loading difficult to control and predict.

21.4.4 Conclusions

Water from Lake Ontario and Skaneateles Lake should not be a significant source of mercury to Onondaga Lake and could result in lower water column concentrations due to dilution. Additionally, the chemicals resulting from the treatment of the water for potable use are not expected to affect the lake. While the changes in flow of the chosen tributary could result in a increased the particle (and therefore mercury) loading to the lake, this outcome is unlikely as contaminated tributary sediments will be remediated prior to implementation of a cooling water system.

21.5 Section Summary

Potential effects of Naturally Chilled Water discharges to Onondaga Lake and Onondaga Creek are reviewed. The effects of any discharges are expected to be minimal.

21.6 References

Addess, J.M., and S.W. Effler. 1996. Summer methane fluxes and fall oxygen resources of Onondaga Lake, New York. Lake and Reservoir Management 12(1): 91-101.

Amyot, M., D.R.S. Lean, L. Poissant, and M.R. Doyon. 2000. Distribution and transformation of elemental mercury in the St. Lawrence River and Lake Ontario. Canadian Journal of Fisheries and Aquatic Sciences 57:155-163.

Benoit, J.M., C.C. Gilmour, A. Heyes, R. P. Mason, and C. L. Miller. 2003. Geochemical and biological controls over methylmercury production and degradation in aquatic ecosystems. In Y. Cai and O. C. Brouds (eds.): Biogeochemistry of environmentally important trace elements, ACS Symposium Series 835, American Chemical Society, Washington, D.C. pp. 262-297.

Benoit, J.M., C.C. Gilmour, and R. P. Mason. 2001. The influence of sulfide on solid-phase mercury bioavailability for methylation by pure cultures of Desulfobulbus propionicus (1pr3). Environmental Science and Technology 35(1): 127-132.

Bloom, N.W., and S.W. Effler. 1990. Seasonal variability in the mercury speciation of Onondaga Lake, NY. Water Air and Soil Pollution 53(3-4): 251-265.

Chapra, S.C. 1997. Surface water quality modeling. McGraw-Hill, New York, NY. 784 pp.

Chen, B., P. Westerhoff, and S.W. Krasner. 2008. Fate and transport of wastewater-derived disinfection by-products in surface waters. In T. Karanfil, S. W. Krasner, P. Westerhoff and Y. Xie (eds): Disinfection By-Products in Drinking Water: Occurrence, Formation, Health Effects, and Control. American Chemical Society, Washington, DC. pp. 257-273.

Cooke, G.D., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1993. Restoration and management of lakes and reservoirs. Lewis Publishers, Boca Raton, FL. 560 pp.

Effler, S.W. 1996. Limnological and engineering analysis of a polluted urban lake. Prelude to environmental management of Onondaga Lake, New York. Springer-Verlag, New York, NY. 832 pp.

Effler, S.W., R.K. Gelda, S. D. Field, A.J.P. Effler, E.B. Wallenberg, and D.A. Matthews. 2005. Changes in primary production in Onondaga Lake, NY: Magnitude, metrics, and drivers. Lake and Reservoir Management 21(1): 49-60.

Effler, S. W., and Matthews, D. A. (2003). Impacts of a soda ash facility on Onondaga Lake and the Seneca River, NY. Lake and Reservoir Management, 19(4), 285-306.

Effler, S. W., and Matthews, D. A. (2008). Implications of redox processes for the rehabilitation of an urban lake, Onondaga Lake, NY. Lake and Reservoir Management, 24, 122-138.

Effler, S. W., O'Donnell, S. M., Matthews, D. A., Matthews, C. M., O'Donnell, D. M., Auer, M. T., and Owens, E. M. (2002). Limnological and loading information and a phosphorus total maximum daily load analysis for Onondaga Lake. Lake and Reservoir Management, 18(2), 87-108.

Effler, S. W., Owens, E. M., Matthews, D. A., O'Donnell, S. M., and Hassett, J. M. (2009). Effects of discharge of spent cooling water from an oligotrophic lake to a polluted eutrophic lake. Journal of Water Resources Planning and Management, ASCE, 135(2), 96-106.

Gelda, R. K., and Auer, M. T. (1996). Development and testing of a dissolved oxygen model for a hypereutrophic lake.Lake and Reservoir Management, 12(1), 165-179.

Gelda, R. K., Effler, S. W., and O'Donnell, S. M. (2001). Probabilistic model of ammonia and toxicity status for urban lake. J. Water Res. Plan. Manage., 127(5), 337-347.

Jassby, A., and Powell, T.M. (1975). Vertical patterns of eddy diffusion during stratification in Castle Lake, California. Limnol. Oceanogr. 20(4), 530-543.

Henry, E. A., L. J. Dodge-Murphy, G. N. Bigham, S. M. Klein, and C. C. Gilmour. 1995. Total mercury and methylmercury mass-balance in an alkaline, hypereutrophic urban lake (Onondaga Lake, NY). Water Air and Soil Pollution 80:509-517.

Jacobs, L. A., S. M. Klein, and E. A. Henry. 1995. Mercury cycling in the water column of a seasonally anoxic urban lake (Onondaga Lake, NY). Water Air and Soil Pollution 80:553-562.

Marvin, C., M. Charlton, J. Milne, L. Thiessen, J. Schachtschneider, G. Sardella, and E. Sverko. 2007. Metals associated with suspended sediments in Lakes Erie and Ontario, 2000-2002. Environmental Monitoring and Assessment 130:149-161.

Matthews, D. A., and Effler, S. W. (2006a). Changes in the hypolimnetic oxygen resources of Onondaga Lake: 1978-2002. Limnol. Oceanogr., 51(1), 702-714.

Matthews, D. A., and Effler, S. W. (2006b). Long-term assessment of the oxygen resources of a recovering urban lake, Onondaga Lake, NY. Lake and Reservoir Management, 22(1), 19-32.

Matthews, D. A., Effler, S. W., Matthews (Brooks), C. M., Siegfried, C. A., and Spada M. E. (2001). Responses of Onondaga Lake, New York, to early stages of rehabilitation: Unanticipated ecosystem feedbacks. Wat. Environ. Res., 73(6), 691-703.

Matthews, D. A., Stehman, S. V., and Effler, S. W. (2002). Limnological and statistical issues for monitoring the impact of a lake source cooling facility: Cayuga Lake, NY. Lake and Reservoir Management, 18(3), 239-256.

NYSDEC (New York State Department of Environmental Conservation). (2004), Onondaga Lake bottom subsite of the Onondaga Lake superfund site, Syracuse, New York, New York State Department of Environmental Conservation, Albany, NY.

NYSDEC. 2009. Part 703: Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations. http://www.dec.ny.gov/regs/4590.html. Accessed on September 24, 2009.

OCDWEP. 2009a. Tour Metro web page. http://www.ongov.net/WEP/we1901.html. Accessed on September 23, 2009.

OCDWEP. 2009b. Onondaga Lake Improvement Project web page. http://ongov.net/lake/.on September 23, 2009.

OCDWEP. 2009c. Onondaga Lake Ambient Monitoring Program 2007 Annual Report (Final Revised April 2009). Available at: http://static.ongov.net/WEP/wepdf/2007_ANNUAL%20REPORT_FINAL_APR09.pdf. Onondaga County Department of Water Environment Protection.

OCWA. 2008. Annual Reports: 2008 Water Quality. Available at: http://www.ocwa.org. Onondaga County Water Authority.

Osterman, J. W. 1990. Evaluating the impact of municipal water fluoridation on the aquatic environment. American Journal of Public Health 80(10): 1230-1235.

Owens, E. M., and Effler, S. W. (1996). Modeling the impacts of a proposed hypolimnetic wastewater discharge on stratification and mixing in Onondaga Lake. Lake and Reservoir Management, 12(1), 195-206.

Perkins, M. G., and Effler, S. W. (1996). Optical characteristics of Onondaga Lake 1968-1990. Lake and Reservoir Management, 12(1), 103-113.

Rowell, C. (1996). Paleolimnology of Onondaga Lake: The history of anthropogenic impacts on lake water quality. Lake and Reservoir Management, 12(1), 35-45.

Rucinski, D. K., Auer, M. T., Watkins, D. W., Jr., Effler, S. W., O'Donnell, S. M., and Gelda, R. K. (2007). Accessing assimilative capacity through a dual discharge approach. J. Water Res. Plan. Manage., 133(6), 474-485.

Tango, P. J., and Ringler, N. H. (1996). The role of pollution and external refugia in structuring the Onondaga Lake fish community. Lake and Reservoir Management, 12(1), 81-90.

TAMS and YEC. 2002. Onondaga Lake remedial investigation report. Prepared for New York State Department of Environmental Conservation, Albany, NY. TAMS, New York, NY and YEC, Valley Cottage, NY.

Todorova, S. G., Driscoll, C. T., Matthews, D. A., Effler, S. W., Hines, M. E., and Henry, E. A. (2009). Evidence for regulation of monomethyl mercury by nitrate in a seasonally stratified, eutrophic lake. Environ. Sci. Technol., 43, 6572-6578.

USEPA (United States Environmental Protection Agency). (1973). Report of Mercury Source Investigation: Onondaga Lake, New York and Allied Chemical Corporation, Solvay, New York. National Field Investigation Center, Cincinnati, Ohio, and Region II, New York, 67 p.

Weinstein, L. H. and A. Davison. 2004. Fluorides in the environment: effects on plants and animals. CABI Publishing, Cambridge, MA. 287 pp.

Yu, M.-H. 2005. Environmental toxicology: biological and health effects of pollutants. CRC Press, Boca Raton, FL. 368 pp.

22.0 Potential Ecological Effects: Invasive Species

22.1 Section Introduction

The Great Lakes are one of the most valuable freshwater systems in the world, yet they are also one of the most heavily invaded. Water-related resources on the Great Lakes, including recreational and tourism activities, are valued at $15 billion annually (Glassner-Shwayder 2000). The addition of invasive species to the Great Lakes can/does have profound effects on those vital resources. Since the 1800's, there are a known 146 invasive aquatic species to have become established in the Great Lakes (Glassner-Shwayder 2000). Of those, approximately 10% are considered harmful, in that they have had significant impacts on ecosystem health (Mills et al. 1998). It is estimated that one new non indigenous species invades the Great Lakes each year (Glassner-Shwayder 2000). Research suggests that the economic loss caused by invasive species, introduced via ballast water, in the Great Lakes is $200 million annually (Lodge and Finnoff 2008).

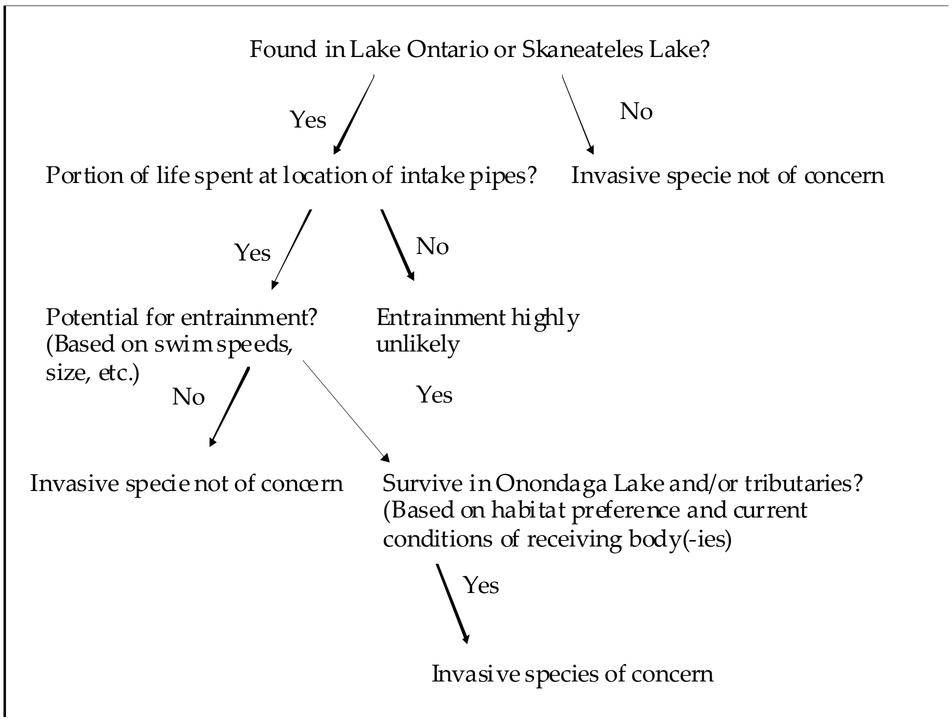
A withdrawal from either Skaneateles Lake or Lake Ontario may result in a discharge to a different receiving body (Onondaga Lake and/or one or more tributaries). It is, therefore, especially important to evaluate the potential for organisms to be successfully transferred from one water body to another, particularly in the case of a Lake Ontario withdrawal, where water will be discharged upstream of the source water body. The introduction of invasive species to a new water body could have profound effects on the ecosystem to which it is introduced. It is, therefore, the goal of this subtask to (1) determine and discuss which invasive species are in Lake Ontario and Skaneateles Lake, particularly ones that are currently found at the possible intake sites and (2) to discuss intake designs and operational strategies that would prevent the entrainment of those invasive species.

22.2 Invasive Species in the Lake Ontario Drainage Basin: A Focus on Organisms Susceptible to Entrainment

The term 'invasive' is commonly used to describe the status of an organism in a given ecosystem. 'Invasive', however, has several definitions and it is important to address the term 'invasive' in the context of this project. Invasive species are considered non-indigenous organisms that have colonized natural habitats.

The Unites States Geological Survey (USGS) maintains a nation-wide database of Nonindigenous Aquatic Species (NAS). It was with this database that a list of invasive species in the Great Lakes region, specifically the Oswego River watershed, was compiled (see Appendix 4). Using the current distributions within the drainage basin, life histories, and the likelihood of inhabiting areas in the vicinity of the intake pipes, it was determined whether or not organisms could be entrained and subsequently survive in the receiving water body(-ies) (Figure 22-1).

Figure 22-1. Decision Tree for Potential Passage and Survival of Invasive Species to Receiving Bodies



Of the 121 invasive species in the Lake Ontario drainage, 27 could be/are present at the approximate location of the proposed intakes (Table 22-1). Of that subset, seven were considered 'risk species', in that there is the potential for their introduction and establishment into a new water body, following entrainment. Included in this list are three fish species, two crustaceans, one protozoan, and one virus.

Table 22-1.Invasive Species That Could Be at the Proposed Locations of the Intakes Pipe(s). Risk Species Are in Bold

Group	Scientific Name	Common Name	In Vicinity of Either Intake?	Survivability in Onondaga Lake	Include as Risk Species?	Justification
Annelids-Oligochaetes	*Potamothrix bedoti*	a tubificid worm	Yes	Yes	n/a	Currently in Onondaga Lake
Annelids-Oligochaetes	*Potamothrix moldaviensis*	a tubificid worm	Yes	Yes	n/a	Currently in Onondaga Lake
Annelids-Oligochaetes	*Potamothrix vejdovskyi*	a tubificid worm	Yes	Yes	n/a	Currently in Onondaga Lake
Arthropoda	*Acentropus niveus*	(European) aquatic/water moth	Yes	Yes	No	Prefers macrophytes Elodea and M. spicatum, both abundant in lake. However, not likely to be found at either intake depths.
Arthropod	*Tanysphyrus lemnae*	aduckweed/ aquatic weevil	Yes	No	No	Prefers floating macrophytes for feeding, which are not very abundant in Onondaga Lake. Unlikely to be found at intakes.
Crustaceans-Amphipods	***Echinogammarus ischnus***	**an amphipod**	**Yes**	**Yes**	**Yes**	**Have been found at depths up to 300 m**
Crustaceans-Amphipods	*Gammarus tigrinus*	an amphipod	Yes	No	No	Littoral zone species, not likely to be found at intake.
Crustaceans-Cladocerans	*Bythotrephes longimanus*	spiny water flea	Yes	No	No	Found in upper water column, not likely near intakes. Can't tolerate warm waters.
Crustaceans-Cladocerans	***Cercopagis pengoi***	**fishhook waterflea**	**Yes**	**Yes**	**Yes**	**May possibly be at intake in Lake Ontario, can live in deep water (not sure how deep, however)**
Crustaceans-Cladocerans	*Eubosmina coregoni*	water flea	Yes	No	No	Occurs at depths of 20-30 m, not likely near intakes.

Table 22-1.Invasive Species That Could Be at the Proposed Locations of the Intakes Pipe(s). Risk Species Are in Bold (Continued)

Group	Scientific Name	Common Name	In Vicinity of Either Intake?	Survivability in Onondaga Lake	Include as Risk Species?	Justification
Crustaceans-Copepods	*Eurytemora affinis*	a calanoid copepod	Yes	No	No	Occurs at depths up to 10 m, not likely near intakes.
Crustaceans-Copepods	*Skistodiaptomus pallidus*	calanoid copepod	Yes	No	No	Occurs at depths 10-16 m, not likely near intakes.
Crustaceans-Mysids	*Hemimysis anomala*	bloody red shrimp	Yes	No	No	Occurs at depths of 6-10 m, not likely near intakes.
Fishes	***Alosa aestivalis***	**blueback herring**	**Yes**	**Yes**	**Yes**	**In vicinity of intake, survivable possible in Onondaga Lake**
Fishes	*Alosa pseudoharengus*	alewife	Yes	Yes, Already Present	No	Already established in Onondaga Lake
Fishes	***Apollonia (Neogobius) melanostomus***	**round goby**	**Yes**	**Yes**	**Yes**	**In vicinity of intake, survivable possible in Onondaga Lake**
Fishes	*Oncorhynchus kisutch*	coho salmon	Yes	No	No	Stocked/managed
Fishes	*Oncorhynchus nerka*	kokanee, sockeye	Yes	No	No	Stocked/managed
Fishes	*Oncorhynchus tshawytscha*	Chinook salmon	Yes	No	No	Stocked/managed
Fishes	***Osmerus mordax***	**rainbow smelt**	**Yes**	**No**	**Yes**	**Survival in Onondaga Lake unlikely**
Mollusks-Bivalves.	*Dreissena polymorpha*	zebra mussel	Yes	Yes	No	Currently in Onondaga Lake
Mollusks-Bivalves	*Dreissena rostriformis bugensis*	quagga mussel	Yes	Yes	No	Currently in Onondaga Lake
Platyhelminthes	*Dugesia polychroa*	a flatworm	Yes	Yes	No	Currently in Onondaga Lake.

Table 22-1.Invasive Species That Could Be at the Proposed Locations of the Intakes Pipe(s). Risk Species Are in Bold (Continued)

Group	Scientific Name	Common Name	In Vicinity of Either Intake?	Survivability in Onondaga Lake	Include as Risk Species?	Justification
Protozoans	***Heterosporis***	**Microsporidian**	**Yes**	**Yes**	**Yes**	**Infects yellow perch, but has the potential to infect numerous fish species including carp, trout, channel catfish and fathead minnows, among others. Can survive for one or more year at 4 C.**
Protozoans	*Myxobolus cerebralis myxosporean*	parasite, salmonid whirling disease	Yes	Yes	No	Infects salmonid species.Oligochaete *Tubifex tubifex* is an obligate host. Could survive in Onondaga Lake, however, entrainment of salmonid species not likely.
Viruses	***Novirhabdovirus sp.***	**Viral Hemorrhagic Septicemia (VHS)**	**Yes**	**Yes**	**Yes**	**The optimal temperature range for replication is 14-15 C. Can persist for several days in water 4 C. Fish mortality is greatest at 3-12 C. If infected fish are entrained, there is the potential for spreading VHS to another water body.**

Aquatic biota that were determined to potentially survive in a newly introduced water body, following entrainment and given current conditions of the receiving water body(-ies), are further discussed in detail:

1 *Echinogammarus ischnus* (amphipod): Is native to the Black and Caspian Sea drainages. It was first introduced to the Great Lakes via ballast waters. It was determined to be established in Lake Ontario and the upper St. Lawrence River in 2000. E. ischnus feeds on macroinvertebrates, such as chironomids, and deposits associated with zebra mussels. It is more carnivorous than the amphipod species *G. fasciatus* and *H. azteca* and has become the dominant amphipod in many benthic communities (Benson and Kipp 2009; Crosier and Molloy, 2000). E. ischnus can tolerate highly eutrophic conditions and temperatures up to 33-35°C, with an optimal temperature range of 20-24°C (Benson and Kipp 2009; Van Overdijk et al. 2000). They have been found at depths up to 300 m, but prefer hard substrates and shallow water (Benson and Kipp 2009; Van Overdijk et al. 2000). It is possible that *E. ischnus* could be at the Lake Ontario intake. In the event of their entrainment, it is possible that E. ischnus could become established in Onondaga Lake.

2 *Cercopagis pengoi* (cladocerans): Commonly known as the fishhook waterflea, this cladoceran is native to the Black, Caspian, Azov and Aral Seas. *C. pengoi* inhabits freshwater and brackish lakes. It is now established in Lake Ontario, Canandaigua Lake, Keuka Lake, Otisco Lake, Cross Lake, Seneca Lake, and the Erie Canal east and west of the Cayuga-Seneca Canal confluence. It was introduced to the Great Lakes region via ballast water introduction. Studies have shown *C. pengoi* densities to increase with distance from shore (Benson et al. 2009). C. pengoi is a consumer of small zooplankton and competes with other planktivores, including alewife and rainbow smelt. They alter the food web, by forcing smaller prey to deeper, cooler water, causing changes in growth rates. Research has found that following their establishment in Lake Ontario, to the lowest alewife population in 20 years had been reported (Benson et al. 2009). It is unsure of how deep C. pengoi has been found, but it could potentially be found at the Lake Ontario intake. If *C. pengoi* were to be entrained and subsequently survive, they could establish themselves in Onondaga Lake given current conditions and their habitat preferences.

3 *Alosa aestivalis* (blueback herring): Are native to the Atlantic coast, from Nova Scotia to Florida and are classified as established in New York. Their expanded range is due in large part to the canal system. Since their establishment, juvenile and/or adult blueback herring have been collected in the Mohawk River (1978), Lake Champlain (1970's), Oneida

Lake (1981-1982; 1994), Lake Ontario (1995) and the Oswego River (Fuller and Jacobs 2009). Blueback herring are planktivorous forage fish. They prefer fast, deep water with a hard substrate (Werner 2004). In lakes, however, blueback herring share very similar habitat preferences to alewife, which inhabit Onondaga Lake. Studies suggest that blueback herring could hinder the recovery of indigenous fish populations, such as cisco and lake trout (Fuller and Jacobs 2009). If blueback herring are found in the vicinity of the proposed intake in Lake Ontario, and they were to be entrained, it is possible that they could survive in Onondaga Lake with current conditions.

4 *Apollonia (Neogobius) melanostomus* (round goby): The round goby is native to Eurasia, specifically the Black Sea, Caspian Sea, and the Sea of Azov and associated tributaries. The round goby was determined established in New York in 1998, with fish collected in the Erie Canal, Buffalo River, St. Lawrence River, Genesee River, Tonawanda Creek, and Lake Ontario (Fuller et al. 2009). They were introduced to the Great Lakes via ballast water. They inhabit a variety of habitats and prey largely on zebra mussels and other invertebrates. Studies have found populations of native fish to decline in the presence of round gobies (Fuller et al., 2009). They compete with native fish for food and spawning sites. They have also been found to prey on juvenile fish, such as smallmouth bass, as well as the eggs of other fish, such as darters and lake trout (Fuller et al. 2009; Werner 2004). The round goby has been found in 21 m of water in the Great Lakes and is known to be tolerant of low-oxygen conditions (Werner 2004). Adult round gobies are often found under stones or partially buried in sand and gravel substrate (Werner 2004). If the round goby were to be entrained, it is possible that they could survive in Onondaga Lake.

5 *Osmerus mordax* (rainbow smelt): Rainbow smelt are indigenous to the Atlantic drainages of North America, Arctic and Pacific drainages from the Northwest Territories and the Pacific drainages of Asia. Rainbow smelt were considered established in the Great Lakes in 1929 (Fuller and Maynard 2009)). In New York, rainbow smelt have been documented in Lake Erie, Lake Ontario, Neversink Reservoir, various Adirondack Lakes and Lake Champlain. Rainbow smelt live in lakes, but migrate to tributaries to spawn. In lake, they are found inhabiting the deep, cold waters (Werner 2004). Rainbow smelt are a problem invader, in that they compete with other fish for food (Fuller and Maynard 2009). Rainbow smelt are found near the proposed location of the intake in Lake Ontario. However, if they were to become entrained, their survival in Onondaga Lake is unlikely, given their preference for deep, cold waters.

6 *Heterosporis* (protozoan): The native range of Heterosporis is unknown as is its mode of introduction into the Great Lakes. In 2000, however, this protozoan was declared established in the eastern end of Lake Ontario. The parasite primarily infects yellow perch, but has the potential to infect numerous fish species including carp, trout, channel catfish and fathead minnows, among others. In the Bay of Quinte, Lake Ontario, research found the population of infected fish to be 5% of the total (Kipp 2009). Fish become infected by ingesting spores found in the water column or decaying fish. Parasitism occurs within the skeletal muscle of the fish. Ultimately, the parasite turns muscle tissue opaque and cloudy. *Heterosporis* survive for one or more year in the water at 4°C (Kipp 2009). It is unlikely that an infected perch will be found at the intake depths. However, without treatment, it may be possible to spread *Heterosporis* if the water at the intake depth is carrying the protozoan. It would then have the potential to infect perch in Onondaga Lake.

7 *Novirhabdovirus* sp. (virus): Viral Hemorrhagic Septicemia (VHS) is native to eastern and western Europe, Japan, the Pacific Coast (Alaska to California) and the Atlantic Coast of North America. VHS was classified as established in Lake Ontario in 2006 and in Skaneateles Lake in 2007. The mode of introduction is into the Great Lakes region is unknown. The kidney and spleen are the organs most targeted by the virus. Symptoms of VHS include hyperactivity, erratic swimming, twisting of the body, and mortality. Some fish show no symptoms of infection. In the acute form, fish become lethargic, dark in color, and anemic. The eyes may bulge, kidneys become congested and the liver becomes mottled. Fish also hemorrhage in the eyes, skin, gills, fin bases, skeletal muscle, and viscera. Acute infection results in higher mortality rates and the disease is short-lived. In the chronic form, mortality is low and symptoms are similar to the acute form, except hemorrhaging is not common. The kidney and spleen accumulate fluid, the body becomes bloated, and the liver and kidneys become light in color. Surviving fish of the virus can be carriers of virus for the rest of their lives. The optimal temperature range for viral replication is 14-15°C, but it can persist for several days in water as cold as 4°C. The optimal pH range for replication is between 7.4-7.8. Research shows that fish mortality is greatest between 3-12°C. VHS affects fish at any age, but it cannot infect eggs. Juvenile fish are more susceptible to infection than adults. VHS is not as virulent to salmon and trout as other species of fish. Large die-offs of freshwater drum, round goby, muskellunge, northern pike, gizzard shad, smallmouth bass, walleye and yellow perch have been observed in the Great Lakes and Thousand Island

areas due to VHS. Currently 50 fish species are known to be susceptible to VHS (Kipp and Ricciardi 2009). If infected fish are entrained, there is the potential for spreading VHS to another water body. Furthermore, if water at the location of the intake is carrying the activated virus it is possible to spread VHS to another water body.

22.3 Intake Design and Operational Strategies

The potential impingement and entrainment of organisms, whether indigenous or non indigenous, should be evaluated and preventative measures taken with regard to intake design and plant operations. Chow et al. (1981) described three concepts to protect aquatic life: deterrence, diversion and removal of resident and migratory species. The deterrence and diversion of organisms are dependent on their behaviors and the use of barriers to repel them. Physical removal is the actual impingement of organisms on the structure. With an understanding of organisms operators are managing for, successful and efficient methods can be employed to prevent impingement and entrainment.

Various barriers and intake screens used to prevent the entrainment of organisms have been described in literature. Such barriers include: louver-type screen, wedgewire screens, fine mesh traveling screens, modified perforated pipe, and granular filter material (e.g., sand and gravel), among others (Chow et al. 1981). Similarly, there are behavioral deterrents that repel organisms from intake pipes. Such devices implement the use of sound, light, electrical fields, and water currents to keep fish and invertebrate species from approaching the intake pipes (Chow et al. 1981). Research suggests that behavioral deterrents are not as successful at preventing impingement and entrainment as fine-screening methods (Uziel et al. 1979). Additionally, studies would suggest that the use of screens is more economically practical (Uziel et al. 1979).

Using the Cornell Lake Source Cooling Project on Cayuga Lake as an example, the use of a 2 mm wedgewire on the intake pipe was the best control measure for preventing entrainment of organisms (Cornell 2006). Additionally, an intake velocity of 7.62 cm/sec was determined a suitable velocity for preventing impingement of various fish species. A light to deter mysids was initially implemented at the facility's intake pipe. The light was lost during maintenance and it was ultimately decided not to replace the light due to the difficulty of maintaining it (Cornell 2006).

The accumulation of organisms, especially zebra and/or quagga mussels, is very likely on the intake screens. Routine mechanical cleaning of the intake screens and pipes (e.g., pigging) may be necessary, particularly if no other deterrent (e.g., chlorination, pipe coatings) is employed.

22.4 Section Summary

Section 316(b) of the Clean Water Act states, "Design and construction technologies for minimizing impingement mortality and entrainment must be selected and implemented…" (Environmental Protection Agency, 2001). Preliminary research suggests that several invasive species found in the Lake Ontario Drainage could invade Onondaga Lake and/or its tributaries if they were successfully entrained in the intake pipes. To prevent the introduction of invasive species to a new water body, it is recommended several operational strategies are employed, including water treatment (e.g. chlorination) and the use of a wedgewire screen at the intake pipe.

23.0 Environmental Impacts Associated with a Chilled Water District

23.1 Section Introduction

In general, environmental impacts may be divided into temporary and long-term impacts. Temporary impacts are those experienced for a short or defined time period, such as during construction. Long-term impacts are those experienced in perpetuity or that have a long-lasting effect on the local environment. The focus of tis Section is to identify and describe the potential short-term environmental impacts associated with the installation of a chilled water delivery system, as well as the potential long-term environmental impacts associated with the potential economic growth within the broad subject area of Oswego and Onondaga Counties.

In order to explore the potential environmental impacts of a Chilled Water Project, it is first necessary to define what physical components comprise the project. Five distinct chilled water delivery system options are described in the previous tasks. The systems described vary from the more intrusive (installation of a redundant transmission pipeline from the Lake Ontario shoreline in Oswego to the City of Syracuse) to less intrusive (reuse of the existing transmission pipelines from Oswego or Skaneateles to the City of Syracuse). Each option considered contains a new heat exchange facility and a chilled water distribution pipeline from the heat exchange facility to the Syracuse chilled water plant. To identify as many potential environmental impacts as possible, Task 8 will consider the most intrusive option (the installation of a new transmission pipeline from the City of Oswego to the City of Syracuse), along with a new heat exchange facility and chilled water distribution pipeline. The environmental impacts identified while considering the most intrusive option should include all of the potential impacts for the less intrusive options, and therefore be an accurate representation of the potential scope of environmental impacts associated with development of a Chilled Water Project in Central New York.

Sections 23.2 identifies and describes the major temporary impacts associated with potential installation of the pipeline; Section 23.3 identifies the long-term environmental impacts associated with the anticipated increases in development and economic growth.

23.2 Impacts Due to Temporary Interruption of Service

23.2.1 Introduction

The temporary, or construction-related, impacts resulting from the installation of the CNY chilled water pipeline are primarily the result of temporary interruption of services and impacted vehicular traffic patterns. The term "services" applies to underground utilities services such as electric, water, sewer and gas, as well as overhead utilities including electric and telephone lines. In addition, the term also applies to the actual road surfaces within Oswego and Onondaga Counties since they provide a means to distribute public safety and emergency services throughout the counties. The term "temporary" can also be vague. Therefore, for the purposes of this report, a short-term service interruption is defined as 1 to 3 hours, while a long-term interruption is defined as 3 to 12 hours. If service interruptions are anticipated to extend beyond 12 hours, an appropriate mitigation plan will be required.

23.2.2 Land Uses

The temporary impacts from the pipeline installation, particularly temporary interruptions in services, are likely to affect residential, commercial, agricultural, industrial, and civic properties across Oswego and Onondaga Counties differently. Therefore, the aforementioned land uses can be used as a means to further delineate the broad reaching temporary impacts. The following are predominant land uses in Oswego and Onondaga Counties:

- Residential
- Agricultural
- Commercial/Industrial
- Civic

In general, the proposed chilled water infrastructure will be located in existing rights-of-way and within previously developed areas. The potential project routes include agriculture, residential, commercial, and industrial land use areas. Temporary impacts resulting from installation of infrastructure can be expected to impact each of these land use types.

23.2.2.a Residential

Temporary or construction-related impacts, particularly interruptions of services, within residential areas are likely to include:

- Driveway blockages
- Increased traffic and congestion as well as lane closures
- Loss of utilities (power, water, etc.)
- Potential public safety/emergency delays

Short-term interruptions in services for residential property can be considered minor inconveniences if the short-term impacts are planned and mitigated. Should these interruptions be long-term and/or unplanned, the impact may be considered more substantial, requiring additional mitigation. Other impacts from construction-related activities may include increased noise as well as physical impacts to landscape. In these instances, proposed mitigation measures may include:

- An interactive public outreach program identifying times and location of construction activities so that residents may plan ahead.
- Establishment of a phone line or web-based help center.
- Proactive construction scheduling to avoid gas/electrical impacts in cold months.
- Site restoration.
- Traffic modification.

23.2.2.b Agricultural

Temporary interruptions of services are not likely to significantly impact agricultural areas since the predominance of agricultural land uses in Oswego and Onondaga Counties does not lie along the proposed routes. However, the potential exists for minor impacts and temporary loss of services to the agricultural properties. In addition to those impacts anticipated in residential areas, temporary interruptions of services for agricultural properties may include potential impacts to existing subsurface drainage systems, potential impacts to existing irrigation systems, and loss of power.

Overall construction-related impacts, including temporary interruption in services, have the potential to result in substantial impacts to agricultural productivity if they are not anticipated and mitigated properly. If these impacts are mitigated, then the anticipated impacts are minimal.

Other impacts to agricultural properties include the compaction of topsoil and the increased potential for erosion and sedimentation. As such, soil conservation best management practices should be implemented at the work site.

Infrastructure and pipeline routes should be planned to avoid impacts. If impacts are unavoidable, mitigation and site restoration are necessary.

23.2.2.c Commercial

The impacts to local businesses are discussed separately under Section 23.2.3b and c.

23.2.2.d Civic

The impacts to local civic spaces (hospitals and public safety facilities) are discussed under Section 23.2.3d and e.

23.2.3 Construction-Related Impacts on Conduct of Business

23.2.3.a Introduction

The major industries within the project area include manufacturing, retail, health care, and government (see Table 4-8). Within each of these industries, several are service/utilities dependent. These local businesses (and agricultural properties) near or adjacent to the proposed CNY chilled water pipeline are subject to a variety of temporary or constructed-related impacts. Although these impacts are temporary, they are likely to result in direct costs and losses in productivity. This is the opposite of the temporary impacts to residential properties, which primarily result in inconveniences for local residents for a short duration and can be mitigated. To minimize costs to local businesses, steps will need to be built into the infrastructure design to avoid interrupting critical utilities, minimize duration of interruptions, and inform local businesses in advance so they may plan accordingly.

23.2.3.b Manufacturing

Many of the area's manufacturing businesses are service/utility dependent. Any temporary interruption in these services will result in a loss of productivity and increase costs to local businesses. Efforts should be made to consult local businesses prior to construction to determine which services are considered vital and what schedule of service interruption, traffic modification, etc. is acceptable.

23.2.3.c Retail

Some retail businesses are service/utilities dependent. Restaurants and salons require substantial quantities of water in order to meet client demand. Temporary interruption in these services could result in lost sales for these businesses.

Staging for pipeline installation is likely to occur in large municipal parking lots, impacting local retail facilities. In addition, the potential traffic impacts (lane closures, congestion) resulting from the installation of the chilled water pipeline can temporarily adversely impact many of the area retail businesses.

23.2.3.d Health Care

Hospitals, clinics, nursing homes, assisted living facilities, and other health care-related businesses in the project area are very dependent on utility service. Most such facilities have emergency generators capable of dealing with electrical outages for short periods without significant adverse affects. Unplanned utility outages lasting longer than a few hours could cause significant problems for health care-related businesses. With notice and planning, the adverse impacts of utility outages can be minimized.

23.2.3.e Government

A variety of civic-based facilities are located throughout Oswego and Onondaga Counties, including municipal buildings, public safety, schools, etc. As with health care-related facilities, governmental facilities typically have emergency generators to provide electricity for short utility outages. Utility outages of longer duration could cause interruption of services, but the potential disruption could be minimized by appropriate planning and communications during construction.

Emergency services provided by governmental agencies could be affected by utility outages and roadway closures. The disruption to services should be minimal since the emergency providers are trained to provide services even during periods of utility outage or weather-related road closures.

23.3 Environmental Consequences of Economic Growth

The need for lower-cost energy for cooling can be divided into two groups: process cooling and comfort cooling (see Section 6). The area's manufacturing facilities are anticipated to grow within the newly created chilled water district. In addition, facilities which implement centralized cooling (i.e., office complexes, data centers) are anticipated customers of the chilled water district. The anticipated economic growth in the manufacturing and commercial sectors is likely to result in construction of new large-scale facilities and complexes dedicated to manufacturing and commercial land uses. Also, the increased economic growth is likely to result in the expansion of existing manufacturing and/or commercial complexes located within the chilled water district.

Anticipated growth resulting from the chilled water district is likely to occur in centralized industrial and commercial areas or may even occur at existing facilities, as opposed to sprawling development in a random format. There are potential environmental consequences and benefits to this type of development. This section identifies and describes these long-term environmental impacts.

Assessing potential environmental impacts requires an understanding of environmental systems, but also requires a defined scope of work, such as an engineering site plan. One works from the scope to review the potential environmental consequences and make an assessment of the potential impacts. Without a scope of work, such as in the case of anticipated economic growth, identifying and assessing environmental impacts becomes more difficult. Therefore, the components of the State Environmental Quality Review (SEQR) were used as a foundation from which the environmental consequences of economic growth can be identified.

Long-term environmental impacts from economic growth in these markets can be broadly categorized as impacts on: (1) land; (2) water; (3) air; (4) plants and animals; (5) agricultural land resources; (6) aesthetic resources; (7) historic and archeological resources; (8) open space and recreation; (9) transportation; (10) energy, noise and odor; (11) public health: and (12) community character.

Note: This Section focuses on the long-term environmental consequences of the anticipated economic growth resulting from the creation of a chilled water district. This section does not discuss the direct environmental impacts (i.e., stream crossings, wetland impacts).

23.3.1 Impact On Land

The boundary of the new chilled water district will be directly related to the extent of the chilled water distribution system. New, sprawling development and subsequent development of green space is not anticipated from the creation of a chilled water district. In general, new industrial or commercial development is likely to occur in centralized or urban locations adjacent to the proposed chilled water distribution system. It is anticipated that new development or expansion of existing facilities will result in development of land which has been historically impacted or altered. Therefore, impacts on land are anticipated to be limited and may include:

- Potential construction of paved parking for 1,000 or more cars.
- Construction on land with shallow water table (less than 3 feet).
- Construction phases greater than one year.

These impacts can be mitigated by designing future growth to meet existing engineering and design standards. Further, this mitigation is likely to be required on a case-by-case basis, and individual projects will be required to comply with state and local environmental regulations and building codes.

23.3.2 Impact On Water

Economic growth and future industrial and commercial developments are likely to result in impacts to local and regional surface waters in a variety of ways. First, the anticipated development within the chilled water district is likely to result in increased impervious surface (buildings, parking, roads) which will result in an increase in stormwater runoff into surface waters. In addition the quantity of industrial discharges to surface waters is likely to increase. As such, impacts to water are likely and mitigation (such as stormwater management) will be required on an individual case basis. The following impacts on water are anticipated:

- Potential development of site containing a protected water body.
- Potential development in a designated wetland.
- Increased stormwater runoff and water quality degradation.
- Potential increase in industrial discharges.
- Additional wastewater treatment needs.

Mitigation of these impacts will consist of two primary measures: stormwater management for surface runoff and wastewater treatment for industrial discharges. In both cases, State Pollutant Discharge Elimination System (SPDES) permits will be required. For stormwater runoff, facilities will be required to obtain a SPDES General Permit for Construction Activities (GP-0-08-01) or Multi-section General Permit for Industrial Activities (GP-06-01). Industrial point source discharges will also require coverage under a SPDES permit.

The development of a chilled water delivery system with a heat exchanger will introduce a potential impact to the potable water system. The proposed heat exchange system includes several safety measures intended to preclude any pollutants from the chilled water loop from being introduced to the potable water system. As with any mechanical system, the proposed system has the potential to fail and could introduce pollutants into the potable water system. The potential impact of the release of such pollutants is mitigated by the proposed use of food grade chemicals for pipe corrosion inhibition on the chilled water side of the heat exchanger. The potable water system is regulated by the New York State Department of Health, and any project constructed must be determined by the Department to satisfactorily maintain the safety of the potable water system.

23.3.3 Impact on Air

The adverse impacts to air quality from the installation and implementation of the Chilled Water Project in Oswego and Onondaga Counties could potentially range from moderate to significant depending on the number and types of industries that participate in the project, such as the manufacturing to power generation industries. Specifically, air quality emissions would come primarily from the processing of solvent-based materials, such as paints and volatile organic compound (VOC)-containing materials, and/or from combustion of fuels. These emissions are monitored and controlled from a mass rate and ambient air concentration basis by the NYSDEC through the Air Resources Permitting Program.

Per NYSDEC regulations, as set forth in the New York State Codes, Rules and Regulations (NYCRR), facilities with sources of non-exempt air emissions must first obtain an approved pre-construction and operating permit prior to the installation and operation of those sources. In New York State, the Air Quality Operating Permit Program, as set forth in 6 NYCRR Part 221, has a three-tiered permitting system: (1) New York State Facility Registration; (2) New York State Facility Permit; and (3) Title V Permit. The type of permit required for a facility is dictated by the comparison of the quantified calculated air emissions at a proposed facility with established air quality emission thresholds.

As such, a potential facility needs to prepare an emissions inventory which identifies and quantifies their source's emission rates on an hourly and annual basis. Once these air emission sources have been identified and quantified, the facility-wide totals are compared with regulatory threshold limits outlined in 6 NYCRR 201.2(b)(21) to determine which air operating permit to obtain. The major source (Title V) regulatory thresholds for Oswego and Onondaga Counties, which are located in the Seasonal Ozone Transport Region are summarized in the following table:.

Table 23-1.Regulatory Thresholds for Air Pollutants in Onondaga and Oswego Counties

Pollutant	Major Source Threshold (Tons/Yr)
Particulate Matter (PM)	100
PM-10	100
PM-2.5	100
Carbon monoxide (CO)	100
Oxides of Nitrogen (NOx)	100
Sulfur dioxide (SO_2)	100
Volatile Organic Carbon	50
Hazardous Air Pollutants (HAP)*	25 (aggregate); 10 (individual)
Note: Complete listing of HAPs is found in 6 NYCRR 200.1 (ag).	

A facility may obtain a New York State Facility Registration if its annual potential-to-emit (PTE) (maximum hourly emission rate multiplied by 8,760 hrs/yr) and/or its actual annual emissions are less than half of the major source thresholds listed above. This permit is the easiest to obtain and does not require periodic renewal unless the facility installs additional emission sources, which would require a permit modification.

To obtain a New York State Facility Permit, the facility's PTE emissions must be below the major source thresholds listed above. A facility can also obtain this permit if its PTE emissions are above the major source thresholds and its actual emissions are below the major source thresholds. In this situation, the facility would voluntarily take a federally-enforceable emissions cap which would essentially limit the hours of operation and/or machine operating capacity and thus limit the emissions below regulatory thresholds. There are some monitoring, record keeping and reporting requirements associated with this permit.

A Title V permit is required for those facilities with air emissions greater than or equal to any of the pollutant major source thresholds listed above. Generally, this permit type has extensive monitoring, record keeping, and reporting requirements. The air emissions are also typically controlled to lower levels via add-on control technologies, such as carbon adsorption, thermal oxidation, and wet scrubbing.

Based on the projected potential industrial participation with the Chilled Water Project, the typical industry source would likely require a New York State Facility Permit.

There would also be an adverse impact of increased greenhouse gas emissions resulting from the increase in industrial activity. Currently in New York State, the amount of greenhouse gases based on carbon dioxide emissions and equivalents from the power generation industry (i.e., electric power plants) is controlled via the Regional Greenhouse Gas Initiative (RGGI) cap and trade system.

The increase in industrial facilities from the proposed Chilled Water Project would most likely occur in existing industrial zoned locations, such as industrial parks, along the chilled water piping route. Many of these industrial parks are currently under-utilized.

The potential increases in air pollution described above should be compared to the potential reductions in air pollution identified in Section 17.

23.3.4 Impact on Plants and Animals

Increased economic growth within the chilled water district could potentially result in a loss of available habitat for species currently utilizing the land. Most of the anticipated economic growth within the chilled water district will occur in areas which have been previously altered. The species which already occur in developed areas are known as habitat generalists. Habitat generalists do not require highly specialized or unique environmental settings to thrive and reproduce. Examples of species considered to be habitat generalists include the common grackle (*Quiscalus quiscula*), American robin (*Turdus migratorius*), or eastern gray squirrel (*Sciurus carolinensis*). The affects on habitat generalists will be minimal due to their ability to conform to their often highly disturbed environment.

Typical plant communities in previously disturbed areas are often made up of non-native invasive species which often thrive and overtake the native species. Examples of such invasive species include phragmites (*Phragmites australis*), black locust (*Robinia pseudoacacia*), or Japanese knotweed (*Polygonum cuspidatum*). For new development occurring at a "green" site, greater environmental precautions should be taken to avoid and/or minimize potential impacts to flora and fauna, including:

- Assessing what ecological cover types exist on site.
- Developing an inventory of wildlife utilizing the site.
- Determining whether the site is part of a wildlife corridor.
- Determining if there are any habitats on the site designated as "critical habitat" for an endangered species.

Prior to commencing new development projects, SEQRA requires that applicants consult with the NYSDEC's Natural Heritage Program and the U.S. Fish and Wildlife Service regarding the presence of rare, threatened, or endangered plants, animals, or significant natural communities. This would apply to potential development within the new chilled water district. Therefore, it is anticipated that significant adverse impacts to flora and fauna would be avoided and/or minimized during the period of potential economic growth.

Further, the opportunity exists to increase biodiversity through the creation of more natural habitats and connective corridors associated with individual developments within the chilled water district. Many of the proposed projects will require local and state review which could potentially include tree replanting. Through smart zoning and planning decisions, future economic development as a result of the chilled water district could result in an increase in biodiversity in areas where limited biodiversity currently exists.

23.3.5 Impact on Agricultural Land Resources

Agricultural districts are primarily located in Southern Onondaga County and scattered throughout parts of Oswego County, largely outside of the proposed chilled water district. Therefore, significant impacts are not anticipated. However, prior to construction, each project should undergo a review of its impact to local agricultural districts as part of SEQR.

23.3.6 Impact on Aesthetic Resources

According to the NYSDEC DEP-00-2 Assessing and Mitigating Visual Impacts, impacts to aesthetic resources are only considered as such if within a viewshed of the designated aesthetic resource. For the expansion of many facilities, this is not likely an issue given the surrounding land uses. However, work proposed along scenic rivers or near state parks may result in visual impacts. Each project will need to be screened individually.

23.3.7 Impact on Historic and Archaeological Resources

Oswego and Onondaga Counties contain a wealth of historical and archaeological resources associated with Native American and early United States history. The Counties contain many identified historical and archaeological sites, and Chilled Water Project development in or near these sites is not anticipated. State and federal programs already in place provide an appropriate level of protection for these resources.

Significant impacts to historic and archeological resources are not anticipated since the majority of the anticipated economic growth and development is likely to occur within the chilled water district on or near previously altered sites. In addition, proposed developments will be required to follow the regulations set forth in Section 106 of the National Historic Preservation Act of 1966. Several locations within Onondaga and Oswego Counties are identified by the New York State Office of Parks, Recreation and Historic Preservation (OPRHP) as being archeologically sensitive areas and/or listed on the State and Federal Register of Historic Places. Increased economic growth as a result of the chilled water district may result in greater pressures placed on these cultural resources.

However, individual project owners are required to comply the New York State SEQRA prior to commencing any new development within the chilled water district. As such, project owners and/or project applicants are required to consult with the OPRHP regarding the proposed action and the potential effect on cultural resources listed in or eligible for inclusion in the National Registers of Historic Places. If impacts from development to cultural resources cannot be avoided, the appropriate Phase I and II cultural resource surveys will need to be preformed, as determined by the OPRHP.

23.3.8 Impact on Open Space and Recreation

Based on a review of published land use data for Oswego and Onondaga Counties, it does not appear that substantial open space and recreational areas existing within an area will likely be affected by the chilled water infrastructure and subsequent economic growth. Several small public parks exist within the chilled water district; however, the proposed development resulting from the creation of a chilled water district must comply with local zoning laws. The proposed development would not affect existing or future recreational opportunity since the chilled water district is likely to be centralized within existing industrial and commercial areas. Further, development within the chilled water district will be required to comply with existing master planning and open space initiatives established by the municipalities within the chilled water district.

23.3.9 Impact on Critical Environmental Areas

The following State-designated critical environmental areas (CEAs) are located in Onondaga and Oswego Counties.

- Sandy Ponds in the Town of Sandy Creek (Oswego County).
- Portions of Nine Mile Creek in the Town of Camillus (Onondaga County).
- The Onondaga Escarpment Corridor, Village of Manlius (Onondaga County).

CEAs are defined as having an exceptional or unique character with respect to one or more of the following: a benefit or threat to human health; a natural setting (e.g., fish and wildlife habitat, forest and vegetation, open space, and areas of important aesthetic or scenic quality); agricultural, social, cultural, historic, archaeological, recreational, or educational values; or an inherent ecological, geological, or hydrological sensitivity to change that may be adversely affected by any change.

Avoiding impacts to areas designated as CEAs is good development practice and will help to maintain the environmental integrity of an area deemed exceptional enough to receive the designation of Critical Environmental Area. If a proposed development cannot avoid a CEA, the appropriate steps defined in the SEQR process are required to be followed in an attempt to minimize and/or mitigate for the effects on the CEA by the proposed development.

23.3.10 Impact on Transportation

Transportation in Oswego and Onondaga Counties consists of both private and public means in the form of trains, vehicles, and air travel.

- Air travel would likely remain the same or slightly increase because the Syracuse Hancock International Airport is located in the City of Syracuse and would be convenient for business shipping and tourists.
- Passenger and freight train business would likely remain the same or slightly increase because the rail system can transport the public and materials within both counties.
- The regional bus service would also likely remain the same or slightly increase because there are routes within both counties and many within the chilled water district.

The increased economic development as a result of the chilled water district is not likely to affect public transportation in the area. Increase in the chilled water district public transportation would be negligible because the transportation routes and infrastructure are well established with extra capacity. Increased vehicle or large truck traffic would also have a negligible increase because development within the chilled water district would be in highly urbanized areas with traffic patterns meant to handle commercial trucking and heavy passenger car numbers.

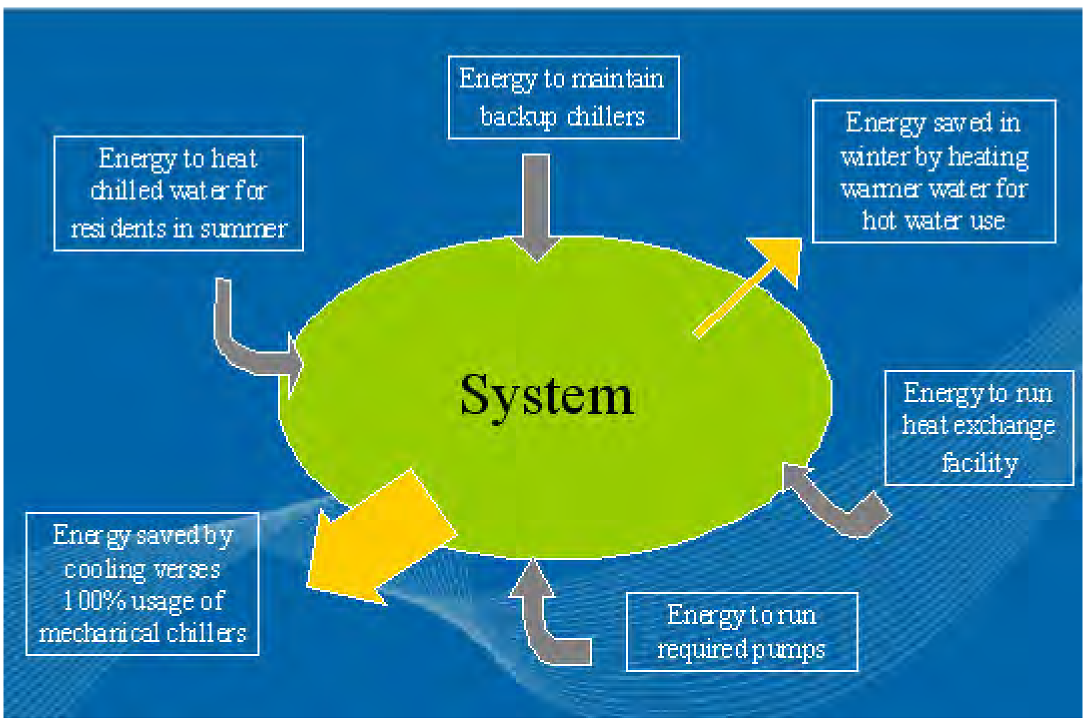
23.3.11 Impact on Energy

Overall, the chilled water district saves energy when compared with current cooling operations. When considering the overall system energy uses and savings, the impact of installing the chilled water system as well as the impact of economic development resulting from the chilled water district must be taken into account. The table below describes the major energy additions and savings associated with installing the chilled water system. Exact energy calculations are dependent on specific location variables and are not calculated at this time, but the approximate values give an idea of the actual energy balance for the implemented system.

Table 23-2.Summary of Energy Costs and Savings for a Naturally Chilled Water System

Energy Used by System	Degree	Energy Saved by System	Degree
Cost to run pumps	Medium	Energy not used by mechanical chillers	Very Large
Residents heating water in summer	Small		
Cost to run heat exchange facility	Small	Residents using less energy to heat water	Small
Energy to maintain backup chillers	Small		

Figure 23-1.Schematic of Energy Changes to Overall System



The system requires some energy consumption by the chilled water owners/operators because the heat exchange facility and chilled water loop need power to pump water, some of the existing mechanical chillers would be maintained as emergency backup, and the daily operations of the heat exchange facility require power. Relative to existing conditions, energy used by this additional equipment and maintenance procedures would not incur a large increase, and the extra energy usage would be mitigated by energy savings from not using the existing mechanical chillers.

In a previous lake source cooling project in Toronto, Canada, residents expressed concern that cooler water entering their homes would require more energy to heat and increase their utility costs. This concern was valid for the Toronto system. The proposed Central New York chilled water system would not change the delivered water temperatures to residential customers sufficiently to validate this concern. In the proposed Central New York chilled water system, the cold water from either Lake Ontario or Skaneateles Lake would pass through a heat exchanger, which would increase the temperature of the water prior to delivery to residential customers. The delivered temperature to residential customers would be relatively unchanged from historical averages.

The potential development occurring as a result of the chilled water district could cause an increase in energy regional usage because there would be more business activity and a rise in population. However, with more economic opportunity in the chilled water district, there would be more potential customers to use cooling provided by the chilled water system, resulting in a larger amount of energy savings compared to traditional cooling methods. Since the proposed development is likely to be centralized within existing industrial and commercial areas, the current energy transmission and supply systems would suffice. The only additional infrastructure needed would be a pipeline from the chilled water loop connecting to the building's cooling system.

The main energy savings from the chilled water system result from not using the existing mechanical chillers. Considering additional equipment due to the chilled water system and considering increased economic development, there would be a net energy savings for the overall system.

23.3.12 Noise and Odor Impacts

Significant adverse noise and odor impacts are not anticipated to result from the anticipated economic growth. However, these impacts should be reviewed for each individual development project as part of the environmental review process.

23.3.13 Impact on Public Health

Significant adverse impacts to public health are not anticipated from the anticipated economic growth. The anticipated users of the chilled water, as outlined in Task 2, include similar types of commercial and industrial businesses currently located within Central New York. As such, the expansion of these facilities in concert with available chilled water is not anticipated to yield direct impacts to public health.

23.3.14 Impact on Growth and Community Character

In general, the long-term impacts to community character should be beneficial. Should economic expansion result from the creation of a chilled water district, the region could benefit from an increase in employment, increase in tax base, and a revitalization of industrial areas. Proposed developments and expansion projects should be completed in accordance with local or regional master plans, avoiding sprawl-type developments. Therefore, impacts to community character resulting from increased economic growth are not anticipated.

23.4 Summary of Impacts of Land Use Change Caused by Creation of Chilled Water District on Local Governments in Onondaga County

23.4.1 Approach

The creation of a chilled water district in Onondaga County may have an impact on land use zoning in the municipalities in which the components of the CNY Chilled Water Project will be located. These components are:

- Intake - Located at the source of the cooling water.
- Transmission Main - Carries the cooling water from the source to the heat exchange facility.
- Heat Exchange Facility and Associated Pump Stations - The heat exchange facility chills the water while pumps move the water through the system.
- Loop Connection - The segregated infrastructure to deliver the chilled water from the heat exchange facility to the end user and back to the heat exchange facility.

- Outfall - The destination for the cooling water once it has been used in the heat exchange facility.

These five components are incorporated into five alternatives, or options, defined for the CNY Chilled Water Project. The five options represent various geographic arrangements of the five components of the system in Oswego and Onondaga Counties; thus, each option will impact the land use zoning of different communities in different ways. To evaluate possible impacts, the zoning codes and comprehensive plans of affected communities were reviewed for each of the five options.

An internet search was conducted to gather information on zoning and planning for the communities likely to be impacted by the CNY Chilled Water Project. The documents used for this review are contained in the bibliography of this section. The results of this review are presented in a matrix in the following section.

23.4.2 Analysis: Matrices

The first step in conducting the analysis was to identify the communities likely to be impacted by the different components of the CNY Chilled Water Project for each of the five options. Conceptual maps of five options under consideration as of August 2009 (Stearns & Wheler) were used as the basis for identifying the potentially affected communities (Table 23-3).

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Table 23-3.Potentially Affected Communities, By Option and Project Component

Component	Option 1	Option 2	Option 3	Option 4	Option 5
Intake	Oswego	Oswego	Oswego	Skaneateles (V) Skaneateles	Skaneateles (V) Skaneateles
Transmission main (new)	Oswego Co. Oswego Minetto Volney Fulton Schroeppel Phoenix (V) Onondaga Co. Clay Salina Salina Syracuse	Oswego Co. Oswego Clay	Oswego Co. Oswego Clay Salina	N/A	N/A
Heat exchange facility	Salina Syracuse	Clay Salina	Salina Syracuse	Geddes	Geddes
Loop connection	Salina Syracuse	Syracuse	Salina Syracuse	Geddes Syracuse	Geddes Syracuse
Outfall		Clay	Dewitt	N/A	Geddes Camillus Van Buren
Notes: N/A = Not applicable; (V) = Village of					

The second step of the analysis involved reviewing the documentation obtained for each community to identify possible impacts to the community for the project component examined. The documentation reviewed is listed in the bibliography of this section. A matrix of the potential impacts to the communities for each of the five options is presented in Table 23-4.

Table 23-4.Matrix of Possible Impacts to Land Use Regulations in Affected Communities, By Option and Project Component

Component	Option 1	Option 2	Option 3	Option 4	Option 5
Intake *Proposed 6 km intake*	Lake Ontario: ***No changes.*** -Oswego (T/V)	Lake Ontario: ***No changes.*** -Oswego (T/V)	Lake Ontario: ***No changes.*** -Oswego (T/V)	Skaneateles Lake: ***No changes.*** -Skaneateles (T/V)	Skaneateles Lake: ***No changes.*** -Skaneateles (T/V)
Transmission main	1. New (Burt Pt. Ext.) -Assumed pipe corridor will utilize existing rights-of-way. ***No changes.*** -Oswego -Minetto -Volney -Fulton -Schroeppel -Phoenix (V) -Clay -Salina	1. New (Burt Pt. Ext.) -Assumed pipe corridor will utilize existing rights-of-way. ***No changes.*** -Oswego 2 Utilize existing infrastructure. ***No changes.*** -Minetto -Volney -Fulton -Schroeppel -Phoenix (V)	1. New (Burt Pt. Ext.) -Assumed pipe corridor will utilize existing rights-of-way. ***No changes.*** -Oswego 2 Utilize existing infrastructure. ***No changes.*** -Minetto -Volney -Fulton -Schroeppel -Phoenix (V) 3. New (42" to heat exchange facility) -Assumed pipe corridor will utilize existing rights-of-way. ***No changes.*** -Clay -Salina	Utilize existing infrastructure. ***No changes.*** -Skaneateles (T/V) -Elbridge -Camillus	Utilize existing infrastructure. ***No changes.*** -Skaneateles (T/V) -Elbridge -Camillus

Table 23-4.Matrix of Possible Impacts to Land Use Regulations in Affected Communities, By Option and Project Component (Continued)

Component	Option 1	Option 2	Option 3	Option 4	Option 5
Proposed heat exchange facility and pump station(s)	1. Salina (Seventh North Street area) zoned residential and industrial. 2. Syracuse (Regional Market area) zoned industrial. 3. Tax parcel land use shows vacant parcels present as possible sites for heat exchange facility.	1. Clay (vicinity of Town Hall) - Zoning primarily residential, agriculture. Special Permit required to site heat exchange facility.	1. Salina (Seventh North Street area) zoned residential and industrial. 2. Syracuse (Regional Market area) zoned industrial. 3. Tax parcel land use shows vacant parcels present as possible sites for heat exchange facility.	1. Geddes (vicinity of Split Rock) - zoned for residential. Special permit would be required to site heat exchange facility. 2. Tax parcel land use shows vacant parcels present as possible sites for heat exchange facility.	1. Geddes (vicinity of Split Rock) - zoned for residential. Special permit would be required to site heat exchange facility. 2. Tax parcel land use shows vacant parcels present as possible sites for heat exchange facility.
Loop connection	Assumed pipe corridor will utilize existing rights-of-way. ***No changes:*** -Salina -City of Syracuse	Assumed pipe corridor will utilize existing rights-of-way. ***No changes:*** -Clay -Salina -City of Syracuse	Assumed pipe corridor will utilize existing rights-of-way. ***No changes:*** -Salina -City of Syracuse	Assumed pipe corridor will utilize existing rights-of-way. ***No changes:*** -Geddes -City of Syracuse	Assumed pipe corridor will utilize existing rights-of-way. ***No changes:*** -Geddes -City of Syracuse

Table 23-4.Matrix of Possible Impacts to Land Use Regulations in Affected Communities, By Option and Project Component (Continued)

Component	Option 1	Option 2	Option 3	Option 4	Option 5
Outfall	New main from heat exchange facility to Onondaga Lake (near Ley Creek). Assumed pipe corridor will utilize existing rights-of-way. ***No changes:*** -Salina -City of Syracuse	New main from heat exchange facility to Oneida River. Assumed pipe corridor will utilize existing rights-of-way. ***No changes:*** -Clay (near Oak Orchard)	1. New main from heat exchange facility to existing Eastern Branch main. Assumed pipe corridor will utilize existing rights-of-way. ***No changes:*** *-Dewitt* 2. Existing Eastern Branch Main to Eastern Reservoir. ***No changes:*** -Manlius	Existing mains to Westcott and Woodland Reservoirs. ***No changes:*** -Geddes -City of Syracuse	1.Existing main to Westcott and Woodland Reservoirs. ***No changes:*** -Geddes -City of Syracuse 2. New main (Westcott to Western Reservoir) Proposed 54" SW Branch) - Assumed pipe corridor will utilize existing rights-of-way. ***No changes:*** -Geddes -Camillus -Van Buren

In summary, the proposed intakes for the five options are located in the source waterbody, and therefore are not affected by land use zoning regulations. The transmission main, the loop connection, and the outfall pipelines are anticipated to follow existing rights-of-way, and therefore no zoning conflicts are expected. However, permits to conduct the work are likely to be required, such as a Highway Work Permit for Utility Work from the New York State Department of Transportation and local road opening permits from affected municipalities. The heat exchange facility and associated pumping stations will occupy land parcels within town boundaries; therefore, land use zoning regulations will need to be reviewed once specific parcels are under consideration.

23.4.3 Options 1 and 3 - Location of the Heat Exchange Facility in Salina or Syracuse

Based on the conceptual design map, the heat exchange facility and associated pump station would be located generally in the vicinity of Seventh North Street near the Regional Market. The border of the Town of Salina and the City of Syracuse runs through this area.

23.4.3.a Town of Salina

The predominant zoning districts in this area are residential and industrial. The dominant tax parcel land uses in this area are residential and commercial, with several parcels categorized as "vacant." Utility service facilities are included under Special Permit Uses (§235-42) and may be sited in most zoning districts, with the caveat that the location, size, and use "will be in harmony with the orderly development of the district."

23.4.3.b City of Syracuse

The predominant zoning districts in this area are industrial. The dominant tax parcel land uses in this area are commercial and industrial, with several parcels categorized as "vacant."

Utility service facilities are included under Part B, Section IV Central Business Districts, Article 4 CBD General Service District. This district, located southeast of the Barge Canal Terminal, "is designed to accommodate those commercial and service uses which are not compatible with business uses as permitted in the other districts." Within the General Service District, the following limits are defined:

- Maximum permitted structural coverage70%
- Maximum permitted parking surface coverage100%
- Floor Area Ratio (F.A.R.) Requirements 2.0

The Board of Zoning Appeals also has the authority (Part A, Section II, Article 5) to permit public service corporations to use property in any district for public utilities purposes if the use is reasonably necessary for the public convenience or welfare, and will not substantially interfere with the use or character of the surrounding property. Utility buildings must conform to the height and yard requirements of the use district, provided that the lot coverage is not more than 35%.

It should be noted that if the City of Syracuse is the owner/developer of the property, it is exempt from the City's zoning restrictions.

23.4.4 Option 2 - Location of the Heat Exchange Facility in Clay

Based on the conceptual design map, the heat exchange facility and associated pump station would be located generally in the vicinity of the Clay Town Hall. The predominant zoning district in this area is RA-100 (Residential/Agricultural). There are a number of parcels identified as “vacant” for tax parcel land use. As a utility substation, a Special Permit (§230-27 Special Permit Review) would be required to construct a facility in this area. The permit application would consist of required forms plus a detailed graphic plan, including a detailed landscaping plan.

The structures on the site will conform to the regulations of the district in which they are located, as well as to any particular regulations which apply under other provisions.

23.4.5 Options 4 and 5 - Location of the Heat Exchange Facility in Geddes

Based on the conceptual design map, the heat exchange facility and associated pump station would be located generally in the vicinity of Taunton and Split Rock. The predominant zoning district in this area is residential (Residential-A). The dominant tax parcel land uses in this area are residential, with several parcels categorized as “vacant.”

The Residential-A district is designated for single-family residences, although there are other uses permitted only upon issuance of a Special Permit. These other uses include facilities for the provision of utility services, specifically natural gas, electrical, land line telephone, and cable television service. There is no specific reference to chilled water as a utility.

23.4.6 Other Potentially-Relevant Local Laws

Noise ordinances may affect the timing of construction activities.

Several Onondaga County municipalities have ordinances regulating connections to existing water mains.

23.5 Conclusions

Given the assumption that transmission main and associated connecting pipelines will be placed in existing rights-of-way, we project no impact on local municipal land use and zoning as a result of the proposed action. As summarized in the matrices, several municipalities would require review and issuance of a Special Permit for construction and operation of the heat exchange facility. Final selection of the site and the specific parcel considered for construction would determine local requirements for sizing, setbacks, height, etc. This conclusion reflects the five alternatives under review as of August 2009.

23.6 Bibliography

This bibliography represents documentation obtained for this review. Most of the documentation was available on-line; these are listed with the web site address and hyperlink.

Table 23-5. Resources for Zoning and Other Information

Political Entity	Resources
Oswego County	
Oswego County	Oswego County Comprehensive Plan.Oswego County Public Information Office. (Not dated). *http://www.oswegocounty.com/planning/compplan.pdf* Oswego County Development Regulation Guide, 1999 with 2009 updates. Oswego County Department of Planning and Community Development. *http://www.co.oswego.ny.us/pdf/devguide2009.pdf*

Table 23-5. Resources for Zoning and Other Information (Continued)

Political Entity	Resources
Fulton (City)	Map 5: Brownfields Opportunity Area Zoning Map, City of Fulton, Oswego County New York. Copyright Laberge Group, 2008. *http://www.oswego-county.com/planning/zoning%20maps/fulton%20map.pdf*
Minetto (Town)	Town of Minetto Zoning Ordinance Existing Zoning Map. Prepared by Oswego County Dept. of Planning and Community Development, December 1999. *http://www.townofminetto.net/images/minetto%20map.pdf* Zoning Ordinance of the Town of Minetto, New York. 2009. *http://www.oswe-gocounty.com/planning/zoning%20maps/minetto%20 zoning%20text.pdf*
Oswego (City)	City of Oswego 2020 Vision Plan. Prepared by Clark Patterson Associates. June 2002. *http://www.oswegony.org/2020Vision.htm*
Oswego (Town)	Town of Oswego Zoning Law. June 22, 2009. *http://www.townofoswego.com/pdfs/zoninglaw2009.pdf* Town of Oswego Zoning Map. Prepared by Oswego County Department of Community Development, Tourism and Planning. June 2, 2009. *http://www.townofoswego.com/pdfs/zoningmap.pdf*
Phoenix (Village)	Village of Phoenix Zoning, Existing Zoning. Prepared by Oswego County Dept. of Planning and Community Development. January 1999. *http://www.oswegocounty.com/planning/zoning%20maps/phoenix%20map.pdf* Village of Phoenix Chapter 205 Zoning. (Note local law is presently proposed before the Board of Trustees) *http://www.oswegocounty.com/planning/zon-ing%20maps/village%20phoenix%20 zoning%20text.pdf*
Volney (Town)	Town of Volney Zoning Ordinance, Existing Zoning Map. Prepared by Oswego County Dept. of Planning and Community Development. August 1998. *http://www.oswegocounty.com/planning/zoning%20maps/vol-ney%20zoning%20 map.pdf* Zoning Ordinances, Town of Volney. Received July 1, 2004 by Oswego County Planning. *http://www.oswegocounty.com/planning/zoning%20maps/vol-ney%20zoning%20 text.pdf*
Onondaga County	
Onondaga County	2010 Development Guide for Onondaga County. Prepared by Syracuse-Onondaga County Planning Agency. June 1998. *http://www.ongov.net/Plan-ning/documents/plan_2010_development_guide.pdf*

Table 23-5. Resources for Zoning and Other Information (Continued)

Political Entity	Resources
Camillus (Town)	Chapter 30: Zoning Regulations of the Town of Camillus. *http://townofcamillus.com/documents/917.pdf* Town of Camillus Zoning Map. Copyright 2006 *http://townofcamillus.com/controls/maps/default.asp?Section=Maps&Page=Zoning& Inner=All*
Clay (Town)	Town of Clay Zoning Code Chapter 230. June 6, 2005, Revised October 1, 2006, Revised October 6, 2008. *http://www.townofclay.org/indexB.html* *Town of Clay, NY.* Chapter 230 Zoning. Adopted 6-6-2005. *http://www.ecode360.com/?custId=CL1598* Town of Clay Zoning Map. *http://www.townofclay.org/indexB.html*
Dewitt (Town)	Summary of Five Local Laws presented to the Town Board of DeWitt August, 11, 2008. Development & Operations, Richard T. Robb, AICP, Commissioner. *http://www.townofdewitt.com/documents/698.pdf* Town of Dewitt Local Law # ___ of the year 2008. (referred to as "A Local Law providing for Comprehensive Miscellaneous Revisions to Chapter 192 of the Code of the Town of Dewitt (Zoning) and related codes.") August 18, 2008. *http://www.townofdewitt.com/documents/692.pdf* Town of Dewitt Zoning Ordinance Chapter 192, adopted 12-10-2007. *http://www.ecode360.com/?custId=DE0337*
Geddes (Town)	Town of Geddes Zoning Code Chapter 240. Printed January 2009. Hard copy obtained from Town of Geddes. Zoning Map, Town of Geddes, County of Onondaga, State of New York. Prepared by W-M Engineers, P.C. 12/1/1984. Hard copy obtained from the Town of Geddes. City of Syracuse-Onondaga County GIS on-line - Tax Parcels Land Use *http://www.maphost.com/syracuse-onondaga/main.asp*

Table 23-5. Resources for Zoning and Other Information (Continued)

Political Entity	Resources
Manlius (Town)	Town of Manlius, Chapter 155 Zoning. Adopted by the Town Board 3-13-1991. *http://www.ecode360.com/?custId=MA1592* Town of Manlius Zoning Map. Copyright C&S engineers, Inc. 2003. *http://gis.csengineers.com/munitrack/manlius/frame_page.cfm*
Marcellus (Town)	Town of Marcellus - 2001 Comprehensive Plan/Final Generic Environmental Impact Statement. Prepared by Barton and Loguidice, P.C. November 2001 *http://www.marcellusny.com/text/comprehensive_plan.pdf* Town of Marcellus, Marcellus, New York. Revised Zoning Ordinance. Effective January 3, 2004. *http://www.marcellusny.com/regulations/zoning_ordinance.pdf* Town of Marcellus, Zoning Map. Prepared by Barton & Loguidice, P.C. Consulting Engineers. Adopted December 8, 2003. *http://www.marcellusny.com/images/Zoning8x14.pdf*
Salina (Town)	Town of Salina, Chapter 235 Zoning. Adopted 7-7-1969, amended in its entirety 1-26-1998. *http://www.ecode360.com/?custId=SA0325* City of Syracuse-Onondaga County GIS on-line - Tax Parcels Land Use *http://www.maphost.com/syracuse-onondaga/main.asp* Town of Salina, Onondaga County, New York Zoning Map. Part of the Zoning Ordinance of the Town of Salina as Adopted by the Town Board of the Town of Salina on 7-7-1969 and amended in its entirety on 1-26-1998. Updated to the May 22, 2006 Town Board Meeting. Prepared by Clough Harbour & Associates LLP, 2005. Hard Copy.
Skaneateles (Town and Village)	Town and Village of Skaneateles Joint Comprehensive Plan. Adopted July 11, 2005. *http://www.villageofskaneateles.com/*

Table 23-5. Resources for Zoning and Other Information (Continued)

Political Entity	Resources
Syracuse (City)	City of Syracuse Comprehensive Plan 2025. Prepared by Clough, Harbour & Associates LLP. January 2005. *http://www.syracuse.ny.us/Pdfs/Comprehensive%20Plan/Full%20Report.pdf* Syracuse Zoning Rules and Regulations - Last Compilation: 12/27/07. *http://www.syracuse.ny.us/zoningOrdinanceListing.asp* City of Syracuse-Onondaga County GIS on-line - Tax Parcels Land Use *http://www.maphost.com/syracuse-onondaga/main.asp* City of Syracuse Zoning Map, sections C2, C3, D1, D2, D3, E1, E2, E3, F1, F2 and F3. Hard copies obtained from Zoning Office, 201 E. Washington St., Syracuse NY.
Van Buren (Town)	Town of Van Buren, Chapter 200 Zoning. Adopted 3-21-2006. *http://www.ecode360.com/?custId=VA1619*

23.7 Potential Consequences of Reduced Potable Water Use for Cooling

At the time of the writing of the work plan for this project, there was a reasonable concern that water used to produce chilled water for cooling purposes would potentially change the amount of potable water available for consumption and other uses within the project area. This concern appears to have been based on the idea that there is a limited amount of water available for either potable or cooling use, and that shifting the existing balance of water usage could create problems. The various options identified for the Central New York chilled water system each rely on either using the existing potable water supply as the source of chilled water or adding an entirely new chilled water intake to supplement the existing potable water supply.

If the existing potable water supply is used as a source for chilled water, the result will be no change in the amount of potable water available for use from the existing amount. This is possible because the proposed chilled water system uses a heat exchanger to transfer the thermal energy from the potable water stream to a separate chilled water stream. The chilled water stream is a sealed loop system and does not actually consume any water. The potable water which passes through the heat exchanger is then transferred to the existing potable distribution network with no reduction in volume.

If an entirely new chilled water intake and transmission system is installed, as is described in one of the options previously presented, the amount of potable water supplied to the City of Syracuse will be completely unaffected. In this case, the cold water from Lake Ontario would be used for cooling and then discharged to Onondaga Lake. The amount of water in Lake Ontario available for potable or cooling use is very large when compared to the existing potable withdrawals or proposed cooling withdrawals considered as a part of this project.

Some existing cooling systems in the Syracuse area use potable water to fill cooling towers and replace cooling water which evaporates or is otherwise wasted. If the cooling provided by any such existing cooling system is replaced by a chilled water system, the amount of potable water used by these customers will decrease. The amount of the reduction would be small when compared to the overall volume of potable water delivered to the City of Syracuse.

23.8 Section Summary

The environmental impacts associated with the construction and operation of a naturally chilled water cooling district should not be significant. While the project as a whole could be quite large, the impacts over the long pipeline route and individual building locations would be widespread and not concentrated. Installation of new buried pipelines within existing utility corridors and under city streets would have minimal impacts on flora and fauna. The new buildings which might be required would have a small footprint and would be in keeping with the type of development already present in each area.

Impacts resulting from additional business with associated traffic and energy usage are not considered significant because the project area has many under utilized commercial structures and infrastructure. These existing facilities could be repopulated with new businesses if the Chilled Water Project provides an economic advantage, and development of exiting green space to new commercial or industrial use is not considered likely. The existing utility and transportation systems have the capacity to support new businesses which could conceivably benefit from the project.

24.0 Permits and Approvals for Naturally Chilled Water Project

24.1 Section Introduction

A project of the magnitude and complexity of the Naturally Chilled Water project will require permits and approvals from federal, state and local governments. In this section, we review the permits and approvals required and present a table with permit requirement by option.

24.2 International Approvals

The Great Lakes-St. Lawrence River Basin Sustainable Water Resources Compact is a good faith agreement among the Great Lakes States (including New York), Canada and the United States Government. Entered into in 2005, the Compact does not directly impose any requirements upon developers in the Great Lakes and St. Lawrence River Basins, but rather is intended to frame the federal, state and provincial laws which will protect these Basins.

24.3 Federal Approvals

New York State's boundary line extends to approximately the middle of Lake Ontario, where the international boundary with Canada is located. See 43 U.S.C. § 1312. The current proposed Lake Ontario water intake line will extend 3.7 miles into the Lake, which means the line will remain entirely within New York jurisdiction except for the Great Lakes Compact application cited above.

The so-called "Three-mile-rule" which gives the Federal government jurisdiction over waters extending more than three miles from the nation's coastlines only applies to ocean coastal boundaries - the Great Lakes are excepted from this rule. Thus, Federal regulatory authority over the Lake Ontario water intake (aside from United States Army Corps of Engineers ("USACE") authority discussed below) is expected to be constrained to the following:

24.3.1 Endangered Species Permit (16 USC § 1531)

Section 9 of the federal Endangered Species Act ("ESA") makes it unlawful for any person to harm any endangered or threatened species. 16 U.S.C. §

1538. "Harm" is broadly defined to include modifications of a species' habitat that would injure a member of the species by significantly impairing its feeding, breeding or other essential activities. See 50 C.F.R. § 17.3. However, the Fish & Wildlife Service, a division of the U.S. Department of Interior, may issue a permit for otherwise lawful activities that may impact an endangered or threatened species or its habitat. If any of the Chilled Water Project's construction activities will impact a federally listed endangered species anywhere along the proposed route, the project operator will be required to apply for this permit or to re-route the project away from the protected area.

24.3.2 Discharge of Fill Material Permit (33 USC §1344)

Construction activities associated with pipeline installation/modification and cooling loop installation will necessarily involve construction and excavation work. To the extent that such work will require the disposal of fill or other material in a navigable waterway (which has a very broad definition), the project operator will be required to apply for one or more permits from the USACE, which regulates construction activities within and near navigable waterways.

24.3.3 National Environmental Policy Act ("NEPA")

NEPA requires all federal entities approving, funding or undertaking a discretionary action to conduct an assessment of the environmental impacts of that action. All potential impacts are evaluated to identify which may be significant, then a further evaluation determines whether such impacts are unavoidable. No federal permits or approvals may be issued for a project until the NEPA review process has been completed. Note that state and local permits and approvals in New York are subject to the State Environmental Quality Review Act ("SEQRA"), which is an analog of the NEPA process and which must be completed independent of whatever review is provided under NEPA. SEQRA compliance for this Project is discussed in the State approvals section below; the chief difference between NEPA and SEQRA is that the latter requires the assessment of mitigative measures to reduce or eliminate potentially significant impacts.

24.4 State Approvals

The Chilled Water Project will require a series of state permits and approvals, the exact number and type of which will depend upon the Project's final design and its chosen route. Some of those approvals involve shared agency jurisdictions that allow for joint applications; for example, stream disturbance permitting for construction within navigable waters involves both the USACE and the New York State Department of Environmental Conservation ("NYSDEC"), and a Joint Application for such approvals must be filed with the agencies to allow their joint consideration and deliberation.

24.4.1 State Environmental Quality Review Act ("SEQRA")

SEQRA requires all New York State and local government entities approving, funding or undertaking a discretionary action to conduct an assessment of the environmental impacts of that action. All potential impacts are evaluated to identify which may be significant, then a further evaluation determines whether such impacts are unavoidable or can be mitigated to the point of non-significance. Projects of considerable size or extensive scope (such as the Chilled Water Project) will generally require preparation of an Environmental Impact Statement ("EIS"), which is intended to assist agencies' decision making by detailing potential impacts and mitigation methods. In situations involving multiple permitting jurisdictions and agencies, SEQRA provides for the selection and establishment of a single "Lead Agency" that coordinates comments from all agencies and drives the review process toward issuance of a set of findings that must be considered during the remaining permit processes. No permits or approvals may be issued for a project until the SEQRA review process has been completed.

24.4.2 State Pollutant Discharge Permit ("SPDES") for Construction Activity, Operations, and Outfall (6 N.Y.C.R.R. §750-1)

New York State, through authorization from the United States Environmental Protection Agency, manages the SPDES program for all point source discharges to surface and groundwater within the State. Three phases of the Chilled Water Project have SPDES implications - construction, operations, and discharge of the water following thermal harvesting.

The discharge of the water following thermal harvesting will likely garner the greatest level of scrutiny from NYSDEC, depending on the final temperature of the water and the ultimate destination. New York has specific regulations governing "thermal discharges" which may change the temperature of water bodies, including lakes.

24.4.3 Wild, Scenic & Recreational Rivers Permit

New York has specific regulations governing rivers which have been determined to possess outstanding scenic, ecological, recreational, historic, and scientific value. If the transmission pipeline will cross or otherwise impact such a designated river, a permit authorizing such activities and restricting the work practices involved in the pipeline construction will be required.

24.4.4 Environmental Conservation Law ("ECL") Article 15 Protection of Water Permit

This permit is required for construction activities which may impact streams, including placing structures in or across a stream, placing fill in or near a stream, and excavation or altering of a stream bank.

24.4.5 ECL Article 15 Water Supply Permit

This NYSDEC permit will be necessary if the chilled water will be treated for potable use or if the pipeline will be used as an emergency backup for drinking water pipelines. Since both Lake Ontario and Skaneateles Lake are both approved public drinking water sources, NYSDE may also seek to review the project for impacts on those permitted uses.

24.4.6 ECL Article 24 Protection of Wetlands Permit

NYSDEC regulates wetlands which exceed 12.4 acres in size, as well as smaller wetlands which are considered significant. Almost all activities in these regulated wetlands required a permit from NYSDEC.

24.4.7 Great Lakes Water Withdrawal Permit (6 NYCRR §675)

This permit is required only for activities which withdraw in excess of 100,000 gallons per day averaged over any consecutive 30-day period and for water withdrawals that result in a water loss from the Great Lakes basin in excess of 2,000,000 gallons per day averaged over any consecutive 30-day period. If the project will not reach those levels, or if it will be operating under an Article 15 drinking water permit, the Great Lakes withdrawal permit is not required.

24.4.8 Section 401 Water Quality Permit (6 NYCRR § 608)

This approval, in conjunction with the USACE permits, ensures that the project activities will not have adverse impacts on state water quality standards.

24.4.9 Office of General Services Easement/License

With few exceptions that do not apply here, New York State has title to all underwater lands within the State. If the intake or transmission pipeline will be located on a lakebed or laid across the bed of a navigable river, it will require a license or easement from the New York State Office of General Services.

24.5 Local Approvals

24.5.1 Zone Change

Depending on the location of the heat exchange facility and the pumping station, the project may require a zone change by the local legislature to accommodate a commercial/ industrial facility.

24.5.2 Building Permit

The construction of any structure within a municipality will trigger a building permit. Such permits are ministerial (non-discretionary), but typically require an inspection upon completion by the local codes office.

24.5.3 Site Plan Approval

The larger structures in the Chilled Water Project, such as the heat exchange facility and pumping station will typically require site plan approval by the local planning board in order to ensure compliance with the local zoning requirements and the aesthetic concerns of the neighborhood.

24.5.4 Highway/Excavation Work

Towns, Cities, Counties and States have jurisdiction over various public highways in New York. Any excavation or pipeline installation along or within these highway rights of way will require a permit from the appropriate highway department.

24.6 Section Summary

Permits for a Naturally Chilled Water Project will be required from federal, state and local governments. The five tables on the following pages provide information as to type of permit/approval, authority granting approval, applicant, and governing law/regulation, arranged by option. See Section 13 for a full discussion of Options 1 - 5.A brief summary of the five options is provided below.

Option 1: Original Concept - Lake Ontario intake with new (non-potable water) transmission pipeline, heat exchange facility in the city, outfall to Onondaga Lake.

Option 2: Lake Ontario intake utilizing existing Metropolitan Water Board pipeline segments; heat exchange facility near Terminal Reservoir.

Option 3: Lake Ontario intake utilizing existing Metropolitan Water Board pipeline segments; heat exchange facility near Seventh North Street.

Option 4: Skaneateles Lake intake utilizing existing city pipeline segments; heat exchange facility near Andrews Gatehouse.

Option 5: Skaneateles Lake intake utilizing existing city pipeline segments, with a connection to potable water from Lake Ontario.

Table 24-1.Matrix of Potential Permits, Licenses and Approvals-Option 1.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Project-Wide				
SEQRA Compliance	Multiple State and Local Authorities ("Coordinated Review")	System Owner/ Operator[b]	If at least one potentially significant adverse environmental impact is identified for the project, the applicant must prepare an EIS to investigate, assess and mitigate the impact(s). This can significantly delay the approval process.	6 NYCRR 617
Record of Compliance	NYSDEC	System Owner/ Operator[b]	May be required as part of any application to NYSDEC: - verifies the applicant's environmental compliance history - identifies prior violations of the ECL	See NYSDEC Record of Compliance Enforcement Guidance Memorandum
Water Capture/Transport (Intake, Pipeline Construction & Operations, Outfall)				
Endangered Species Permit	United States Fish and Wildlife Service System Owner/ Operator	System Owner/ Operator[b]	May be required if endangered species will be impacted by project	16 USC 1531

Table 24-1.Matrix of Potential Permits, Licenses and Approvals-Option 1.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Discharge of Fill Material Permit	United States Army Corps of Engineers ("USACE")	System Owner/ Operator[b]	May be required if dredged or fill material will be discharged into wetlands	33 USC 1344
State Pollutant Discharge Elimination System ("SPDES") Permit for Construction Activity	New York State Department of Environmental Conservation ("NYSDEC")	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Wild, Scenic and Recreational Rivers Permit	NYSDEC	System Owner/ Operator[b]	May be required for any river crossings which are classified as "wild, scenic, or historical." Varying standards apply depending on the classification on the river.	6 NYCRR 666.8
Article 15 Protection of Water	NYSDEC	System Owner/ Operator[b]	May be required to minimize disturbance of streams and other water bodies during construction, dredging, fill and other activities	6 NYCRR 608
Article 24 Wetlands	NYSDEC	System Owner/ Operator[b]	May be required if construction, dredging, fill or related activities will occur on wetlands or adjacent areas	6 NYCRR 663

Table 24-1.Matrix of Potential Permits, Licenses and Approvals-Option 1.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Record of Compliance[c]	NYSDEC	System Owner/ Operator[b]	May be required as part of any application to NYSDEC: - verifies the applicant's environmental compliance history - identifies prior violations of the New York State Environmental Conservation Law ("ECL")	See NYSDEC Record of Compliance Enforcement Guidance Memorandum
Highway Work Permit (State)	New York State Department of Transportation	Construction Manager/Contractor	Covers any construction-related work to be performed within the State right-of-way	NYS Highway Law § 52
Article 15 Water Supply Permit	NYSDEC	System Owner/ Operator[b]	Covers distribution of potable water. While this permit is required only for public drinking water supply systems, the possibility that the pipeline may be used as a backup potable water transmission main in the event of an emergency could trigger this permit requirement.	6 NYCRR 601

Table 24-1.Matrix of Potential Permits, Licenses and Approvals-Option 1.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Erosion Area Permit	City of Oswego	Construction Manager/Contractor	Required for work conducted within areas marked on Coastal Erosion Hazard Area Map for the City of Oswego	Oswego City Code
Building Permit	City of Oswego Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the City	Oswego City Code § 126-11
Excavating Permit	City of Oswego Department of Public Works	Construction Manager/Contractor	Covers any disturbance of public street, highway or bridge for installation of pipeline.	Oswego City Code § 245-7
County Highway Work Permit	Oswego County Highway Department	Construction Manager/Contractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	
County Utility Work Permit	Onondaga County Highway Department	Construction Manager/Contractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	
Street Cut Permit (City of Syracuse)	City of Syracuse Department of Public Works	Construction Manager/Contractor	Needed for new pipeline installation in public ways within City of Syracuse	

Table 24-1.Matrix of Potential Permits, Licenses and Approvals-Option 1.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Great Lakes Water Withdrawal Registration[d]	NYSDEC	System Owner/ Operator[b]	Registration only required for water withdrawals exceeding 100,000 gallons per day within Great Lakes Basin. If such a withdrawal will also result in an inter-basin diversion, approval of each governor of the eight (8) Great Lake States and the New York State legislature is also required.	6 NYCRR 675
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
SPDES Discharge Permit for Intake/ Transport Line	NYSDEC	System Owner/ Operator[b]	Required if the operations will result in the discharge of wastewater into surface or ground waters	6 NYCRR 750-1
SPDES Discharge Permit for Outfall	NYSDEC	System Owner/ Operator[b]	Required for discharges to surface water; NYSDEC regulations governing thermal discharges and changes in lake water temperature may apply	.6 NYCRR 750-1; 6 NYCRR 704

Table 24-1.Matrix of Potential Permits, Licenses and Approvals-Option 1.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Section 401 Water Quality Certificate	NYSDEC	System Owner/ Operator[b]	Ensures any discharges to waters of the state do not impair water quality standards	6 NYCRR 608
Construction of Pumping Station in Oswego and Heat Exchange Facility near Seventh North Street, Syracuse				
Zone Change	City of Oswego / City of Syracuse	System Owner/ Operator[b]	Needed if the zoning classification of the target parcel does not permit the proposed use (i.e., industrial or commercial use)	
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Building Permit	City of Syracuse Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the City	
Building Permit	City of Oswego Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the City	Oswego City Code § 126-11
Site Plan Approval	City of Oswego/ City of Syracuse	System Owner/ Operator[b]	Required from each affected municipality	

a. The list of applicable permits/licenses/approvals is subject to change as additional information is received regarding the precise location and layout of the system.

b. The applicant for many permits will depend on the organizational structure and division of responsibilities for developing and operating the chilled water system

c. A Record of Compliance is not a permit, but may be required in conjunction with a NYSDEC permit application.

d. If an Article 15 Protection of Water Permit has been issued by NYSDEC, this registration requirement does not apply

Table 24-2.Matrix of Potential Permits, Licenses and Approvals-Option 2.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Project-Wide				
SEQRA Compliance	Multiple State and Local Authorities ("Coordinated Review")	System Owner/ Operator[b]	If at least one potentially significant adverse environmental impact is identified for the project, the applicant must prepare an EIS to investigate, assess and mitigate the impact(s). This can significantly delay the approval process.	6 NYCRR 617
Record of Compliance	NYSDEC	System Owner/ Operator[b]	May be required as part of any application to NYSDEC: - verifies the applicant's environmental compliance history - identifies prior violations of the ECL	See NYSDEC Record of Compliance Enforcement Guidance Memorandum
Water Capture/Transport (Intake, Pipeline Construction & Operations, Outfall)				
Endangered Species Permit	United States Fish and Wildlife Service System Owner/ Operator	System Owner/ Operator[b]	May be required if endangered species will be impacted by project	16 USC 1531
Discharge of Fill Material Permit	United States Army Corps of Engineers ("USACE")	System Owner/ Operator[b]	May be required if dredged or fill material will be discharged into wetlands	33 USC 1344

Table 24-2.Matrix of Potential Permits, Licenses and Approvals-Option 2.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
State Pollutant Discharge Elimination System ("SPDES") Permit for Construction Activity	New York State Department of Environmental Conservation ("NYSDEC")	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Wild, Scenic and Recreational Rivers Permit	NYSDEC	System Owner/ Operator[b]	May be required for any river crossings which are classified as "wild, scenic, or historical." Varying standards apply depending on the classification on the river.	6 NYCRR 666.8
Article 15 Protection of Water	NYSDEC	System Owner/ Operator[b]	May be required to minimize disturbance of streams and other water bodies during construction, dredging, fill and other activities	6 NYCRR 608
Article 24 Wetlands	NYSDEC	System Owner/ Operator[b]	May be required if construction, dredging, fill or related activities will occur on wetlands or adjacent areas	6 NYCRR 663
Highway Work Per mit (State)	New York State Department of Transportation	Construction Manager/Contractor	Covers any construction-related work to be performed within the State right-of-way	NYS Highway Law § 52

Table 24-2.Matrix of Potential Permits, Licenses and Approvals-Option 2.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Article 15 Water Supply Permit	NYSDEC	System Owner/ Operator[b]	Existing water supply permit may need to be modified to address new intake.	6 NYCRR 601
Erosion Area Permit	City of Oswego	Construction Manager/Contractor	Required for work conducted within areas marked on Coastal Erosion Hazard Area Map for the City of Oswego	Oswego City Code
Building Permit	City of Oswego Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the City	Oswego City Code § 126-11
Excavating Permit	City of Oswego Department of Public Works	Construction Manager/Contractor	Covers any disturbance of public street, highway or bridge for installation of pipeline.	Oswego City Code § 245-7
County Highway Work Permit	Oswego County Highway Department	Construction Manager/Contractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	
County Utility Work Permit	Onondaga County Highway Department	Construction Manager/Contractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	
Street Cut Permit (City of Syracuse)	City of Syracuse Department of Public Works	Construction Manager/Contractor	Needed for new pipeline installation in public ways within City of Syracuse	

Table 24-2.Matrix of Potential Permits, Licenses and Approvals-Option 2.

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Great Lakes Water Withdrawal Registration[c]	NYSDEC	System Owner/ Operator[b]	Registration only required for water withdrawals exceeding 100,000 gallons per day within Great Lakes Basin. If such a withdrawal will also result in an inter-basin diversion, approval of each governor of the eight (8) Great Lake States and the New York State legislature is also required.	6 NYCRR 675
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
SPDES Discharge Permit for Intake/ Transport Line	NYSDEC	System Owner/ Operator[b]	Required if the operations will result in the discharge of wastewater into surface or ground waters	6 NYCRR 750-1
SPDES Discharge Permit for Outfall	NYSDEC	System Owner/ Operator[b]	Required for discharges to surface water; NYSDEC regulations governing thermal discharges and changes in lake water temperature may apply	.6 NYCRR 750-1; 6 NYCRR 704

Table 24-2.Matrix of Potential Permits, Licenses and Approvals-Option 2.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Section 401 Water Quality Certificate	NYSDEC	System Owner/ Operator[b]	Ensures any discharges to waters of the state do not impair water quality standards	6 NYCRR 608
Construction of Pumping Station in Oswego and Heat Exchange Facility near Terminal Reservoir				
Zone Change	City of Oswego / Town of Clay	System Owner/ Operator[b]	Needed if the zoning classification of the target parcel does not permit the proposed use (i.e., industrial or commercial use)	
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Building Permit	Town of Clay Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the Town of Clay	
Building Permit	City of Oswego Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the City	Oswego City Code § 126-11
Site Plan Approval	City of Oswego/ City of Syracuse	System Owner/ Operator[b]	Required from each affected municipality	

a. The list of applicable permits/licenses/approvals is subject to change as additional information is received regarding the precise location and layout of the system.

b. The applicant for many permits will depend on the organizational structure and division of responsibilities for developing and operating the chilled water system

c. If an Article 15 Protection of Water Permit has been issued by NYSDEC, this registration requirement does not apply.

Table 24-3.Matrix of Potential Permits, Licenses and Approvals-Option 3.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Project-Wide				
SEQRA Compliance	Multiple State and Local Authorities ("Coordinated Review")	System Owner/ Operator[b]	If at least one potentially significant adverse environmental impact is identified for the project, the applicant must prepare an EIS to investigate, assess and mitigate the impact(s). This can significantly delay the approval process.	6 NYCRR 617
Record of Compliance	NYSDEC	System Owner/ Operator[b]	May be required as part of any application to NYSDEC: - verifies the applicant's environmental compliance history - identifies prior violations of the ECL	See NYSDEC Record of Compliance Enforcement Guidance Memorandum
Water Capture/Transport (Intake, Pipeline Construction & Operations, Outfall)				
Endangered Species Permit	United States Fish and Wildlife Service System Owner/ Operator	System Owner/ Operator[b]	May be required if endangered species will be impacted by project	16 USC 1531

Table 24-3.Matrix of Potential Permits, Licenses and Approvals-Option 3.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Discharge of Fill Material Permit	United States Army Corps of Engineers ("USACE")	System Owner/ Operator[b]	May be required if dredged or fill material will be discharged into wetlands	33 USC 1344
State Pollutant Discharge Elimination System ("SPDES") Permit for Construction Activity	New York State Department of Environmental Conservation ("NYSDEC")	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Wild, Scenic and Recreational Rivers Permit	NYSDEC	System Owner/ Operator[b]	May be required for any river crossings which are classified as "wild, scenic, or historical." Varying standards apply depending on the classification on the river.	6 NYCRR 666.8
Article 15 Protection of Water	NYSDEC	System Owner/ Operator[b]	May be required to minimize disturbance of streams and other water bodies during construction, dredging, fill and other activities	6 NYCRR 608
Article 24 Wetlands	NYSDEC	System Owner/ Operator[b]	May be required if construction, dredging, fill or related activities will occur on wetlands or adjacent areas	6 NYCRR 663

Table 24-3.Matrix of Potential Permits, Licenses and Approvals-Option 3.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Highway Work Per mit (State)	New York State Department of Transportation	Construction Manager/Con-tractor	Covers any construction-related work to be per-formed within the State right-of-way	NYS Highway Law § 52
Article 15 Water Supply Permit	NYSDEC	System Owner/ Operator[b]	Existing water supply per-mit may need to be modi-fied to address new intake.	6 NYCRR 601
Erosion Area Per-mit	City of Oswego	Construction Manager/Con-tractor	Required for work con-ducted within areas marked on Coastal Ero-sion Hazard Area Map for the City of Oswego	Oswego City Code
Building Permit	City of Oswego Department of Code Enforcement	Construction Manager/Con-tractor	Required for construction of any structure within the City	Oswego City Code § 126-11
Excavating Permit	City of Oswego Department of Pub-lic Works	Construction Manager/Con-tractor	Covers any disturbance of public street, highway or bridge for installation of pipeline.	Oswego City Code § 245-7
County Highway Work Permit	Oswego County Highway Depart-ment	Construction Manager/Con-tractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	
County Utility Work Permit	Onondaga County Highway Depart-ment	Construction Manager/Con-tractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	

Table 24-3.Matrix of Potential Permits, Licenses and Approvals-Option 3.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Street Cut Permit (City of Syracuse)	City of Syracuse Department of Public Works	Construction Manager/Contractor	Needed for new pipeline installation in public ways within City of Syracuse	
Great Lakes Water Withdrawal Registration[c]	NYSDEC	System Owner/ Operator[b]	Registration only required for water withdrawals exceeding 100,000 gallons per day within Great Lakes Basin. If such a withdrawal will also result in an inter-basin diversion, approval of each governor of the eight (8) Great Lake States and the New York State legislature is also required.	6 NYCRR 675
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
SPDES Discharge Permit for Intake/ Transport Line	NYSDEC	System Owner/ Operator[b]	Required if the operations will result in the discharge of wastewater into surface or ground waters	6 NYCRR 750-1
SPDES Discharge Permit for Outfall	NYSDEC	System Owner/ Operator[b]	Required for discharges to surface water; NYSDEC regulations governing thermal discharges and changes in lake water temperature may apply	.6 NYCRR 750-1; 6 NYCRR 704

Table 24-3.Matrix of Potential Permits, Licenses and Approvals-Option 3.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Section 401 Water Quality Certificate	NYSDEC	System Owner/ Operator[b]	Ensures any discharges to waters of the state do not impair water quality standards	6 NYCRR 608
Construction of Pumping Station in Oswego and Heat Exchange Facility near Terminal Reservoir				
Zone Change	City of Oswego / Town of Clay	System Owner/ Operator[b]	Needed if the zoning classification of the target parcel does not permit the proposed use (i.e., industrial or commercial use)	
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Building Permit	Town of Clay Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the Town of Clay	
Building Permit	City of Oswego Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the City	Oswego City Code § 126-11
Site Plan Approval	City of Oswego/ City of Syracuse	System Owner/ Operator[b]	Required from each affected municipality	

a. The list of applicable permits/licenses/approvals is subject to change as additional information is received regarding the precise location and layout of the system.

b. The applicant for many permits will depend on the organizational structure and division of responsibilities for developing and operating the chilled water system

c. If an Article 15 Protection of Water Permit has been issued by NYSDEC, this registration requirement does not apply.

Table 24-4.Matrix of Potential Permits, Licenses and Approvals-Option 4.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Project-Wide				
SEQRA Compliance	Multiple State and Local Authorities ("Coordinated Review")	System Owner/ Operator[b]	If at least one potentially significant adverse environmental impact is identified for the project, the applicant must prepare an EIS to investigate, assess and mitigate the impact(s). This can significantly delay the approval process.	6 NYCRR 617
Record of Compliance	NYSDEC	System Owner/ Operator[b]	May be required as part of any application to NYSDEC: - verifies the applicant's environmental compliance history - identifies prior violations of the ECL	See NYSDEC Record of Compliance Enforcement Guidance Memorandum
Water Capture/Transport (Intake, Pipeline Construction & Operations, Outfall)				
Endangered Species Permit	United States Fish and Wildlife Service System Owner/ Operator	System Owner/ Operator[b]	May be required if endangered species will be impacted by project	16 USC 1531

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Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Discharge of Fill Material Permit	United States Army Corps of Engineers ("USACE")	System Owner/ Operator[b]	May be required if dredged or fill material will be discharged into wetlands	33 USC 1344
State Pollutant Discharge Elimination System ("SPDES") Permit for Construction Activity	New York State Department of Environmental Conservation ("NYSDEC")	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Wild, Scenic and Recreational Rivers Permit	NYSDEC	System Owner/ Operator[b]	May be required for any river crossings which are classified as "wild, scenic, or historical." Varying standards apply depending on the classification on the river.	6 NYCRR 666.8
Article 15 Protection of Water	NYSDEC	System Owner/ Operator[b]	May be required to minimize disturbance of streams and other water bodies during construction, dredging, fill and other activities	6 NYCRR 608
Article 24 Wetlands	NYSDEC	System Owner/ Operator[b]	May be required if construction, dredging, fill or related activities will occur on wetlands or adjacent areas	6 NYCRR 663

Table 24-4.Matrix of Potential Permits, Licenses and Approvals-Option 4.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Highway Work Per mit (State)	New York State Department of Transportation	Construction Manager/Contractor	Covers any construction-related work to be performed within the State right-of-way	NYS Highway Law § 52
Article 15 Water Supply Permit	NYSDEC	System Owner/ Operator[b]	Existing water supply permit may need to be modified to address new intake.	6 NYCRR 601
County Utility Work Permit	Onondaga County Highway Department	Construction Manager/Contractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	
Building Permit	Village of Skaneateles Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the Village	Village Code § 76-11
Critical Impact Use Permit	Village of Skaneateles	Construction Manager/Contractor	Required for development within the Skaneateles Lake watershed	Village Code § 225-52
Street Cut Permit (City of Syracuse)	City of Syracuse Department of Public Works	Construction Manager/Contractor	Needed for new pipeline installation in public ways within City of Syracuse	
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1

Table 24-4.Matrix of Potential Permits, Licenses and Approvals-Option 4.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
SPDES Discharge Permit for Intake/ Transport Line	NYSDEC	System Owner/ Operator[b]	Required if the operations will result in the discharge of wastewater into surface or ground waters	6 NYCRR 750-1
SPDES Discharge Permit for Outfall	NYSDEC	System Owner/ Operator[b]	Required for discharges to surface water; NYSDEC regulations governing thermal discharges and changes in lake water temperature may apply	.6 NYCRR 750-1; 6 NYCRR 704
Section 401 Water Quality Certificate	NYSDEC	System Owner/ Operator[b]	Ensures any discharges to waters of the state do not impair water quality standards	6 NYCRR 608
Construction of Pumping Station in Village of Skaneateles and Heat Exchange Facility near City of Syracuse				
Zone Change	City of Syracuse / Village of Skaneateles	System Owner/ Operator[b]	Needed if the zoning classification of the target parcel does not permit the proposed use (i.e., industrial or commercial use)	
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Building Permit	Village of Skaneateles Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the Village	Village Code § 76-11

Table 24-4.Matrix of Potential Permits, Licenses and Approvals-Option 4.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Building Permit	City of Syracuse Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the City	
Site Plan Approval	City of Syracuse/ Village of Skaneateles	System Owner/ Operator[b]	Required from each affected municipality	City Zoning Code, Article X; Village Code §225-29

a. The list of applicable permits/licenses/approvals is subject to change as additional information is received regarding the precise location and layout of the system.

b. The applicant for many permits will depend on the organizational structure and division of responsibilities for developing and operating the chilled water system

Table 24-5.Matrix of Potential Permits, Licenses and Approvals-Option 5.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Project-Wide				
SEQRA Compliance	Multiple State and Local Authorities ("Coordinated Review")	System Owner/ Operator[b]	If at least one potentially significant adverse environmental impact is identified for the project, the applicant must prepare an EIS to investigate, assess and mitigate the impact(s). This can significantly delay the approval process.	6 NYCRR 617
Record of Compliance	NYSDEC	System Owner/ Operator[b]	May be required as part of any application to NYSDEC: - verifies the applicant's environmental compliance history - identifies prior violations of the ECL	See NYSDEC Record of Compliance Enforcement Guidance Memorandum
Water Capture/Transport (Intake, Pipeline Construction & Operations, Outfall)				
Endangered Species Permit	United States Fish and Wildlife Service System Owner/ Operator	System Owner/ Operator[b]	May be required if endangered species will be impacted by project	16 USC 1531

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Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Discharge of Fill Material Permit	United States Army Corps of Engineers ("USACE")	System Owner/ Operator[b]	May be required if dredged or fill material will be discharged into wetlands	33 USC 1344
State Pollutant Discharge Elimination System ("SPDES") Permit for Construction Activity	New York State Department of Environmental Conservation ("NYSDEC")	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Wild, Scenic and Recreational Rivers Permit	NYSDEC	System Owner/ Operator[b]	May be required for any river crossings which are classified as "wild, scenic, or historical." Varying standards apply depending on the classification on the river.	6 NYCRR 666.8
Article 15 Protection of Water	NYSDEC	System Owner/ Operator[b]	May be required to minimize disturbance of streams and other water bodies during construction, dredging, fill and other activities	6 NYCRR 608
Article 24 Wetlands	NYSDEC	System Owner/ Operator[b]	May be required if construction, dredging, fill or related activities will occur on wetlands or adjacent areas	6 NYCRR 663

Table 24-5.Matrix of Potential Permits, Licenses and Approvals-Option 5.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Highway Work Per mit (State)	New York State Department of Transportation	Construction Manager/Contractor	Covers any construction-related work to be performed within the State right-of-way	NYS Highway Law § 52
Article 15 Water Supply Permit	NYSDEC	System Owner/ Operator[b]	Existing water supply permit may need to be modified to address new intake.	6 NYCRR 601
Erosion Area Permit	City of Oswego	Construction Manager/Contractor	Required for work conducted within areas marked on Coastal Erosion Hazard Area Map for the City of Oswego	Oswego City Code
Building Permit	City of Oswego Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the City	Oswego City Code § 126-11
Excavating Permits	City of Oswego Department of Public Work	Construction Manager/Contractor	Covers any disturbance of public street, highway or bridge for installation of pipeline.	Oswego City Code § 245-7
County Highway Work Permit	Oswego County Highway Department	Construction Manager/Contractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	
County Utility Work Permit	Onondaga County Highway Department	Construction Manager/Contractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	

Table 24-5.Matrix of Potential Permits, Licenses and Approvals-Option 5.

Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Building Permit	Village of Skaneateles Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the Village	Village Code § 76-11
Critical Impact Use Permit	Village of Skaneateles	Construction Manager/Contractor	Required for development within the Skaneateles Lake watershed	Village Code § 225-52
County Utility Work Permit	Onondaga County Highway Department	Construction Manager/Contractor	Permit is required for all utility (i.e., power, water and gas) lines that will transect County roads and highways.	
Street Cut Permit (City of Syracuse)	City of Syracuse Department of Public Works	Construction Manager/Contractor	Needed for new pipeline installation in public ways within City of Syracuse	
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
SPDES Discharge Permit for Intake/ Transport Line	NYSDEC	System Owner/ Operator[b]	Required if the operations will result in the discharge of wastewater into surface or ground waters	6 NYCRR 750-1
SPDES Discharge Permit for Outfall	NYSDEC	System Owner/ Operator[b]	Required for discharges to surface water; NYSDEC regulations governing thermal discharges and changes in lake water temperature may apply	.6 NYCRR 750-1; 6 NYCRR 704

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Type of Permit/ License/Approval[a]	Approval Authority	Applicant	Remarks	Governing Law / Regulation
Section 401 Water Quality Certificate	NYSDEC	System Owner/ Operator[b]	Ensures any discharges to waters of the state do not impair water quality standards	6 NYCRR 608
Construction of Pumping Station in Village of Skaneateles and Heat Exchange Facility near City of Syracuse				
Zone Change	City of Syracuse / Village of Skaneateles	System Owner/ Operator[b]	Needed if the zoning classification of the target parcel does not permit the proposed use (i.e., industrial or commercial use)	
SPDES Permit for Construction Activity	NYSDEC	System Owner/ Operator[b]	May be required to address erosion control, storm water pollution prevention and other construction-related issues	6 NYCRR 750-1
Building Permit	Village of Skaneateles Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the Village	Village Code § 76-11
Building Permit	City of Syracuse Department of Code Enforcement	Construction Manager/Contractor	Required for construction of any structure within the City	
Site Plan Approval	City of Syracuse/ Village of Skaneateles	System Owner/ Operator[b]	Required from each affected municipality	City Zoning Code, Article X; Village Code §225-29

a. The list of applicable permits/licenses/approvals is subject to change as additional information is received regarding the precise location and layout of the system.

b. The applicant for many permits will depend on the organizational structure and division of responsibilities for developing and operating the chilled water system

25.0 Framework for Implementation of Naturally Chilled Water in Central New York

25.1 Section Introduction

In connection with the feasibility study being undertaken with respect to the Central New York Natural Chilled Water Project (the "CNY Project"), this Memorandum outlines in general terms alternative forms for organizing a municipal chilled water district based largely on pre-existing models used in other jurisdictions.

Included as part of the discussion are examples of other municipalities which have existing municipal district cooling systems and their type of organization. Specific details relating to the Naturally Chilled Water Project's organization and administration will vary depending upon the framework selected.

25.2 Discussion

Based on a review of existing chilled water districts in other municipalities across the United States, three models appear to have been used in other municipalities to structure district cooling systems. They include: (1) privatization of chilled water districts; (2) establishment of not-for-profit cooperatives by governmental and private entities to manage a chilled water district; and (3) employing private management schemes for all or part of a chilled water district.

25.2.1 Privatization of Chilled Water Districts.

In several cities, municipal chilled water districts are run by privately-held companies, whereby private entities own the utility distribution system and are responsible for its operation and maintenance. Under this scenario, a municipality could sell a pre-established chilled water district, including the utility infrastructure associated with it, or the rights to build such a district to a private company. This option has the potential benefit of generating new sales revenue for the municipality that could be devoted to non-utility uses, while relieving the municipality of the burdens associated with owning, managing and operating a chilled water district. A private entity also may have the benefit of private sector resources such as financing and efficiencies which could help to further develop the chilled water district. An obvious drawback is loss of ownership and control. Further, there needs to be a willing buyer. Cities in which private entities are owning and operating district cooling systems include:

- **Trenton, New Jersey.** In Trenton, New Jersey, a district heating system (analogous to district cooling systems) is being built by a private concern, the Cogeneration Development Company of New York City. The cost of construction is being absorbed by the private entity. Plans for a district cooling system are in development stages, but will largely depend on current on-going negotiations between the City and another private utility for the sale of the Trenton Water Works' suburban infrastructure (including 462 miles of the 625 miles of water mains), pending approval by the New Jersey State Board of Public Utilities.
- **San Diego, California.** San Diego, California's district cooling system services over four square miles of downtown San Diego. Its cooling system was originally built in 1971 by an affiliate of local utility San Diego Gas and Electric and is now owned and operated by NRG Energy Inc., a private entity. NRG maintains a chilled-water plant and 4 trench miles of chilled-water piping pursuant to which it provides chilled water to its customers for air conditioning. Thus, San Diego's district cooling system is privately owned and operated and the municipality does not appear to be involved with the service.

25.2.2 Establishment of Not-for-Profit Cooperatives.

In other municipalities, governmental entities have partnered with the private sector to establish not-for-profit cooperatives to provide heating and cooling districts. Under this model, the municipality chooses to operate a district via a not-for-profit corporation that is tax-exempt. A primary benefit of this model appears to be the ability to operate a district in a separate entity with separate financing, operation and oversight functions which has the added advantage of combining public and private resources. Set forth below are examples of two municipalities which have adopted a form of this model.

- **St. Paul, Minnesota.** The largest hot water district heating system in North America currently resides in St. Paul, Minnesota and is owned and serviced by a not-for-profit corporation called District Energy. District Energy was founded in 1979 under the name "District Heating Development Company" by the City of St. Paul, the St. Paul Building Owners and Managers Association and the State of Minnesota. The organization was supported by business and labor organizations and concerned citizens. As a private, non-profit corporation, District Energy has no shareholders or other owners. It is governed by a board of directors comprised of three City-appointed members, three customer-elected members and a seventh member chosen by the other six. A seventh member elected by district cooling customers serves on the board of directors of District Energy's affiliate, District Cooling St. Paul, which is also a private non-profit corporation that provides district cooling service to downtown St. Paul building owners.

The heating and cooling entities, collectively, own and maintain the facilities needed to provide heating and cooling to customers and provide the services pursuant to service contracts entered into with customers. The St. Paul heating and water districts have been reported to be successful ventures given the cooperative public and private efforts that were undertaken by all interested parties to develop the projects.

- **Rochester, New York.** Rochester District Heating ("RDH") is a not-for-profit cooperative that provides the City of Rochester with steam-based district heating services. It was formed in 1985 by members of private industry, local government and other non-profit organizations. RDH invites eligible customers to join as members and enter into a service contract for the provision of services. According to RDH's website, RDH appears to own and maintain its own generation facilities. A district cooling cooperative that would be an affiliate of RDH has been proposed, but not yet developed.

25.2.3 Use of Private Management

Another model for organizing a municipal chilled water district is for a municipality to retain ownership of the district and contract-out its operation and maintenance to a private entity. Under this model, the municipality continues to own the system and remains responsible for maintenance, improvements and upgrades depending on its contractual agreement with the private entity, but the day to day management and service is performed by a third party. Research did not yield any findings of a municipality using this model, but there are variations that use elements of it such as in Chicago, Illinois

- **Chicago, Illinois**. Thermal Chicago Corporation, a wholly-owned subsidiary of Macquarie Infrastructure Company, a publicly listed company on the New York Stock Exchange, provides district cooling to commercial and industrial facilities in downtown Chicago, Illinois. To serve the downtown Chicago area, Thermal Chicago has an agreement with the City of Chicago granting specific rights of way in the streets and public ways throughout the downtown area, as well as under and through various other structures. It is believed that Thermal Chicago owns and operates its own cooling facilities but it is unclear whether it also owns other utility infrastructure or whether such is owned by the City and managed by Thermal Chicago.

25.2.4 Municipal Establishment of a For-Profit Corporation

A fourth model which is interesting because it appears to have been developed after previous attempts to establish a not-for-profit structure proved unsuccessful is a municipality's participation in a for-profit venture with other private entities. As further described below, the City of Toronto originally sought to create a district cooling system under a not-for-profit model. However, due to various constraints, it reorganized and established a for-profit entity.

- **Toronto, Ontario, Canada.** Toronto's district cooling system which uses the coldness of Lake Ontario to cool buildings in downtown Toronto was originally formed as part of a not-for-profit cooperative established over 20 years ago under the name "Toronto District Heating Corporation." The cooperative's members included the five district energy systems operating in Toronto, consisting of the University of Toronto, Hospitals Steam Corporation, Toronto Hydro, Queen's Park and the Toronto Terminal Railways Corporation. Collectively, the five entities integrated their respective systems into one entity for the purpose of providing heating and then cooling to institutional and government buildings in downtown Toronto.

  Due to restrictions based on its not-for-profit corporate structure and legislative covenants which made it difficult for the Corporation to raise capital to finance growth, Toronto District Heating Corporation restructured itself in 1998 as a private, for-profit entity called Enwave. A copy of Enwave's articles of incorporation which are included as part of the The Toronto District Heating Corporation Act, 1998, as passed by the Ontario legislature, is included as part of this memo and provides some guidance on the current structure of Toronto's district cooling system.

  Under its current structure, the City of Toronto in partnership with the City's other district energy systems is a shareholder of Enwave and participates in Enwave's governance by having members on its board of directors. Enwave's Articles of Incorporation provide that Enwave is responsible for setting and collecting on its rates for service subject to the rules of the Ontario Energy Board, and further provides that Enwave will enter into agreements with affected municipalities to provide for use of transportation structures. The Ontario Municipal Board is also involved in some capacity in connection with Enwave's agreements with applicable municipalities.

25.3 Conclusion

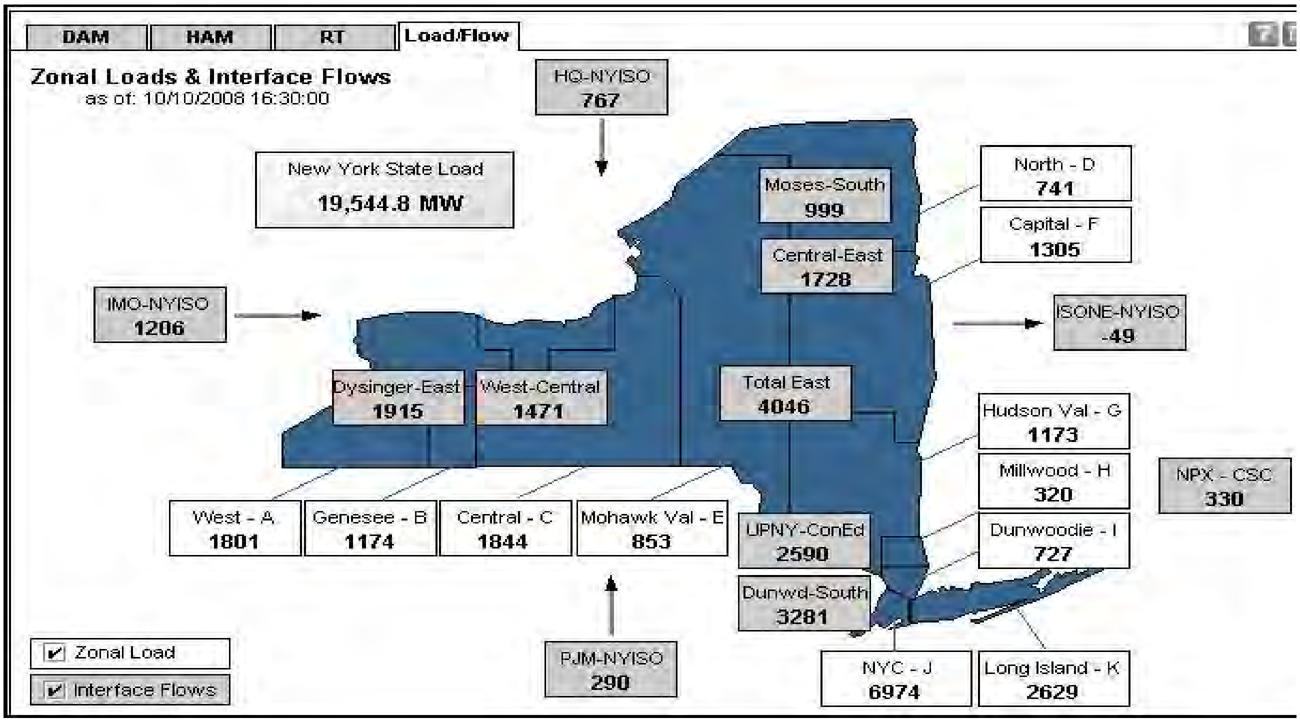
Several models and variations on those models have been used by different municipalities in the organization of chilled water districts, including privatization of some or all aspects of a chilled water district and use of not-for-profit cooperatives. Considerations such as financing, regulation, infrastructure development and a number of other factors have led municipalities to different organizational structures. This Memorandum is intended to provide a general overview of some of the models that have been used which will be helpful to the Naturally Chilled Water Project.

26.0 Appendix 1 - New York State Energy Profile

26.1 Section Introduction

Information as to electricity demand and other energy data for all regions of New York State are presented.

Figure 26-1. Regional Electricity Demand - New York State. Source: NY Independent Systems Operators web site, www.nyiso.com (Repeated from Section 5).



The following tables provide energy usage by regions identified in the figure above.

Table 26-1. Historic Annual Energy Use by Zone[a]- GWh

Year	A	B	C	D	E	F	G	H	I	J	K	NYCA[b]
1997	18,450	8,225	16,223	4,708	9,201	11,777	8,697	1,954	5,436	44,463	18,241	147,374
1998	18,207	8,408	14,878	5,488	9,545	11,781	8,956	1,958	5,702	46,076	18,856	149,855
1999	18,210	8,611	16,713	6,184	8,956	11,994	9,266	1,894	6,060	48,281	19,671	154,841
2000	16,785	9,635	16,182	6,527	8,182	11,398	9,304	1,952	5,929	49,183	20,072	155,140
2001	16,209	9,661	16,034	6,374	7,403	11,429	9,396	2,003	5,782	50,227	20,723	155,420
2002	16,355	9,935	16,356	6,450	7,116	11,302	9,970	2,162	5,962	51,356	21,544	158,507
2003	15,942	9,719	16,794	5,912	6,950	11,115	10,451	2,219	6,121	50,829	21,960	158,013
2004	16,102	9,888	16,825	5,758	7,101	11,161	10,696	2,188	6,216	52,073	22,203	160,211
2005	16,498	10,227	17,568	6,593	7,594	11,789	10,924	2,625	6,435	54,007	22,948	167,208
2006	15,998	10,003	16,839	6,289	7,339	11,337	10,417	2,461	6,274	53,096	22,185	162,237

Source: NYISO 2007 Load and Capacity Data

a. See Figure 5-5 for location and name of zones.

b. New York Control Area.

Table 26-2.Historic Summer Non-Coincident Peak Demand by Zone- MWs

Year	A	B	C	D	E	F	G	H	I	J	K
1997	2,936	1,582	2,728	609	1,432	2,195	2,133	452	1,225	9,670	4,273
1998	2,788	1,589	2,697	764	1,585	2,139	2,045	497	1,269	9,586	4,396
1999	2,976	1,583	2,627	789	1,446	2,225	2,321	543	1,358	10,473	4,782
2000	2,625	1,694	2,170	884	1,216	1,919	2,178	586	1,265	9,809	4,386
2001	2,745	1,938	2,764	806	1,304	2,107	2,401	549	1,397	10,602	4,901
2002	2,770	1,898	2,879	804	1,361	2,114	2,097	562	1,364	10,457	5,082
2003	2,611	1,790	2,745	762	1,223	2,170	2,146	579	1,395	10,240	4,993
2004	2,523	1,743	2,601	705	1,149	1,997	2,041	502	1,366	9,769	4,728
2005	2,787	2,037	3,042	823	1,360	2,254	2,296	632	1,492	11,162	5,295
2006	2,786	2,144	3,153	845	1,435	2,380	2,497	627	1,545	11,360	5,572

Table 26-3.Historic Summer Coincident Peak Demand by Zone - MWs

Year	A	B	C	D	E	F	G	H	I	J	K	NYCA
1997	2,837	1,529	2,718	559	1,411	2,188	2,109	349	1,198	9.596	4,205	28,699
1998	2,643	1,442	2,381	623	1,465	1,998	2,045	419	1,168	9,581	4,396	28,161
1999	2,769	1,564	2,615	669	1,273	2,169	2,321	429	1,277	10,467	4,758	30,311
2000	2,462	1,644	2,459	757	1,185	1,872	2,176	417	1,265	9,771	4,130	28,138
2001	2,519	1,889	2,719	780	1,260	2,068	2,361	537	1,347	10,602	4,900	30,982
2002	2,631	1,842	2,787	777	1,252	2,073	2,076	498	1,335	10,321	5,072	30,664
2003	2,510	1,782	2,727	671	1.208	2,163	2,146	498	1,395	10,240	4,993	30,333
2004	2,493	1,743	2,585	644	1,057	1,953	2,041	475	1,280	9,742	4,420	28,433
2005	2,726	1,923	2,897	768	1,314	2,164	2,236	592	1,409	10,810	5,236	32,075
2006	2,735	2,110	3,128	767	1,435	2,380	2,436	596	1,467	11,300	5,585	33,939

Table 26-4.Forecast of Annual Energy by Zone - GWh

Year	A	B	C	D	E	F	G	H	I	J	K	NYCA
2007	15,654	10,472	17,181	6,783	6,849	11,523	10,770	2,677	6,741	53,291	22,643	165,214
2008	15,738	10,731	17,353	6,995	6,822	11,480	10,909	2,719	6,841	54,940	22,912	167,440
2009	15,855	10,959	17,518	7,147	6,846	11,563	11,050	2,772	6,966	55,719	23,075	169,470
2010	16,032	11,208	17,629	7,227	6,943	11,600	11,199	2,805	7,063	56,708	23,330	171,744
2011	16,261	11,454	17,733	7,285	7,054	11,641	11,345	2,830	7,150	57,709	23,570	174,032
2012	16,504	11,689	17,824	7,323	7,225	11,694	11,479	2,840	7,219	58,899	23,919	176,615
2013	16,776	11,915	17,939	7,346	7,410	11,752	11,602	2,844	7,283	59,770	24,122	178,759
2014	17,149	12,137	18,070	7,295	7,656	11,823	11,712	2,818	7,304	60,744	24,418	181,126
2015	17,548	12,357	18,199	7,230	7,911	11,901	11,820	2,785	7,315	61,747	24,731	183,544
2016	17,855	12,583	18,318	7,241	8,084	11,971	11,935	2,784	7,376	62,907	25,202	186,256
2017	18,077	12,827	18,420	7,307	8,225	12,025	12,051	2,806	7,472	63,977	25,541	188,728

Table 26-5.Forecast of Non-Coincident Summer Peak Demand by Zone - MW

Year	A	B	C	D	E	F	G	H	I	J	K
2007	2,709	2,709	3,022	899	1,505	2,288	2,340	649	1,634	11,780	5,422
2008	2,724	2,131	3,053	927	1,499	2,279	2,370	659	1,658	11,875	5,485
2009	2,744	2,176	3,082	948	1,504	2,296	2,401	672	1,689	12,150	5,541
2010	2,775	2,225	3,101	958	1,526	2,303	2,433	680	1,712	12,325	5,607
2011	2,814	2,274	3,120	966	1,550	2,311	2,465	686	1,733	12,480	5,664
2012	2,856	2,321	3,136	971	2,588	2,322	2,494	688	1,750	12,645	5,730
2013	2,903	2,365	3,156	974	1,628	2,333	2,521	689	1,766	12,780	5,791
2014	2,968	2,410	3,179	967	1,682	2,347	2,545	683	1,771	12,915	5,855
2015	3,037	2,453	3,202	959	1,738	2,363	2,568	675	1,773	13,030	5,919
2016	3,090	2,498	3,222	960	1,776	2,377	2,593	675	1,788	13,140	6,002
2017	3,128	2,547	3,240	969	1,807	2,387	2,619	680	1,812	13,360	6,076

Table 26-6. Forecast of Coincident Summer Peak Demand by Zone (MW) Before Reductions for Emergency Demand Response Programs

Year	A	B	C	D	E	F	G	H	I	J	K	NYCA
2007	2,593	2,017	2,925	811	1,367	2,247	2,262	618	1,505	11,780	5,322	33,477
2008	2,607	2,607	2,956	837	1,361	2,238	2,291	627	1,528	11,975	5,384	33,871
2009	2,626	2,111	2,984	855	1,366	2,254	2,321	639	1,555	12,150	5,439	34,300
2010	2,656	2,159	3,003	864	1,386	2,262	2,352	647	1,577	12,325	5,503	34,734
2011	2,694	2,206	3,020	871	1,408	2,269	2,383	653	1,597	12,480	5,560	35,141
2012	2,734	2,251	3,306	876	1,442	2,280	2,411	655	1,612	12,645	5,624	35,566
2013	2,779	2,295	3,055	879	1,479	2,291	2,437	656	1,626	12,780	5,685	35,962
2014	2,841	2,338	3,078	873	1,528	2,305	2,460	650	1,631	12,915	5,747	36,366
2015	2,907	2,380	3,100	865	1,579	2,320	2,483	642	1,633	13,030	5,810	36,749
2016	2,958	2,423	3,120	866	1,613	2,334	2,507	642	1,647	13,140	5,891	37,141
2017	2,994	2,470	3,137	874	1,641	2,344	2,531	647	1,669	13,360	5,964	37,631

Source: NYISO 2007 Load and Capacity Data.

.

Table 26-7. Historical NYS Commercial Energy Prices in Nominal Dollars

Year	Coal $/ton	Distillate cents/gal	Residual $/bbl	Kerosene cents/gal	Propane cents/gal	Natural gas $/Mcf	Electricity $/kWh	GDP Deflators 2006=1
1992	40.43	75.42	18.17	78.31	85.24	5.76	10.76	0.696
1993	38.39	73.32	18.13	75.09	83.25	6.15	11.23	0.715
1994	38.60	71.45	19.39	75.92	94.12	6.52	11.27	0.736
1995	38.61	70.20	21.01	72.70	91.62	6.07	11.48	0.757
1996	36.82	83.30	25.38	81.43	102.02	6.88	11.62	0.779
1997	37.12	76.23	21.62	84.45	98.07	6.49	11.68	0.796
1998	29.62	60.94	14.98	59.90	86.94	6.10	11.04	0.809
1999	32.00	65.31	17.47	73.63	88.61	5.15	10.33	0.827
2000	40.03	110.34	28.92	127.50	113.46	7.72	12.10	0.854
2001	40.35	93.60	25.60	117.94	120.22	9.57	12.24	0.878
2002	44.09	88.40	25.90	106.91	107.95	6.73	11.79	0.892
2003	39.15	109.87	34.21	134.66	127.37	8.50	12.93	0.913
2004	41.75	134.80	33.71	162.11	142.61	10.21	12.98	0.937
2005	46.88	188.48	47.59	214.92	160.14	12.88	14.36	0.969
2006	63.11	218.07	55.30	245.87	199.38	12.10	13.59	1.000
Source: NYSERDA, Patterns and Trends, 2008								

Table 26-8. Historical NYS Industrial Energy Prices in Nominal Dollars

Year	Coal $/ton	Distillate cents/gal	Residual $/bbl	Kerosene cents/gal	Propane cents/gal	Natural gas $/Mcf	Electricity $/kWh	GDP Deflators 2006=1
1992	42.71	76.44	18.17	65.94	85.24	4.94	6.50	0.696
1993	41.56	70.30	18.13	65.31	83.25	5.16	6.67	0.715
1994	41.50	70.51	19.39	69.47	74.76	5.22	6.78	0.736
1995	41.31	67.08	21.01	60.22	73.96	4.67	5.79	0.757
1996	40.19	81.54	25.38	77.17	78.18	5.04	5.62	0.779
1997	41.27	74.78	21.62	70.72	86.41	5.05	5.20	0.796
1998	36.75	57.93	14.98	54.18	80.40	4.03	4.94	0.809
1999	36.70	64.79	17.47	62.50	82.04	3.90	4.76	0.827

Table 26-8. Historical NYS Industrial Energy Prices in Nominal Dollars (Continued)

Year	Coal $/ton	Distillate cents/gal	Residual $/bbl	Kerosene cents/gal	Propane cents/gal	Natural gas $/Mcf	Electricity $/kWh	GDP Deflators 2006=1
2000	40.60	105.25	28.92	111.49	110.83	6.10	5.37	0.854
2001	41.46	91.62	25.60	90.79	109.79	7.69	5.56	0.878
2002	50.17	88.50	25.90	81.43	103.96	5.80	5.18	0.892
2003	45.25	107.90	34.21	109.77	128.11	7.27	7.14	0.913
2004	54.30	127.39	33.71	137.92	144.82	8.13	7.04	0.937
2005	65.16	190.14	47.59	181.85	157.90	9.88	8.23	0.969
2006	78.19	220.00	55.30	208.03	196.59	10.71	8.62	1.000
Source: NYSERDA, Patterns and Trends, 2008								

27.0 Appendix 2 - Syracuse and Onondaga County Building Inventory

27.1 Introduction

We present data on building in Syracuse and Onondaga County, limited to those with a floor space greater than 25,000 square feet.We begin with several figures summarizing the data.

27.2 Data Summary

Figures 27-1 through 27-6 provide information as to the commercial buildings in Ondaga County (Figures 27-1 to 27-3) and the City of Syracuse (Figures 27-4 to 27-6).

Figure 27-1.Commercial Buildings in Onondaga County by Ranges of Square Footage

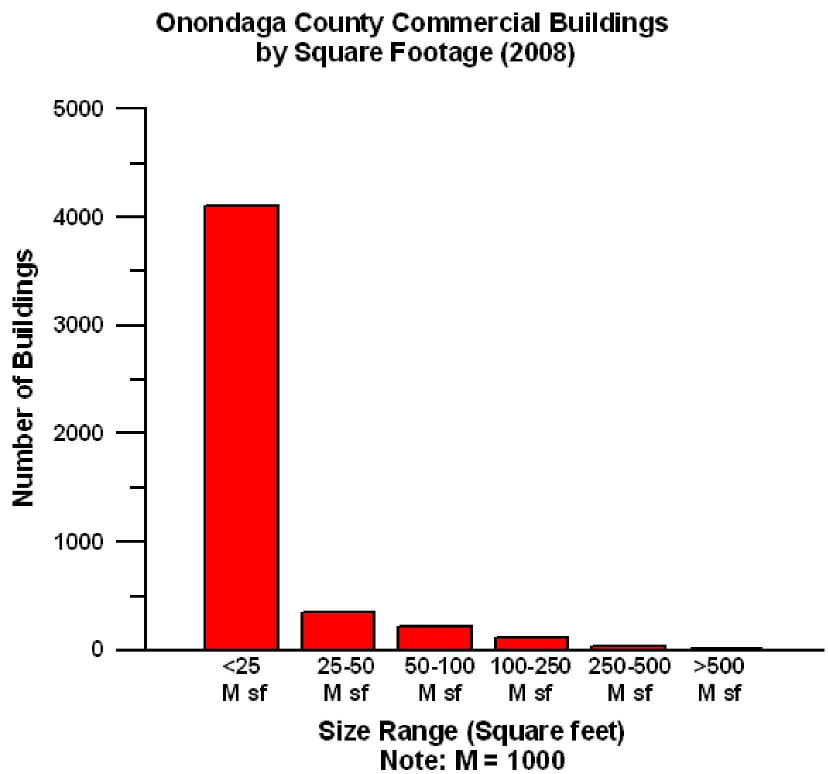


Figure 27-2.Location of Onondaga County Commercial Buildings by Town.

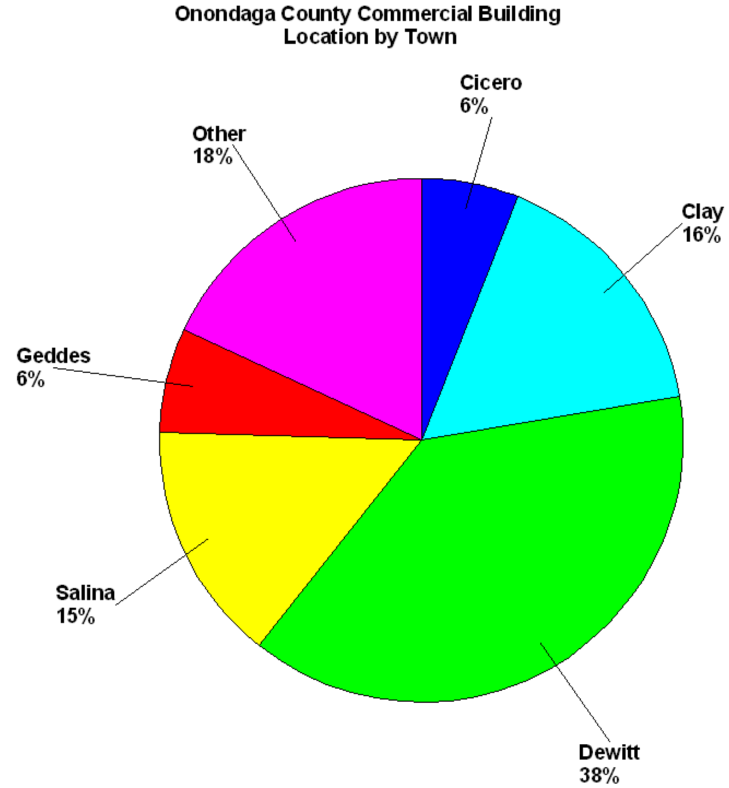


Figure 27-3.Onondaga County Commercial Buildings by Square Footage and Usage

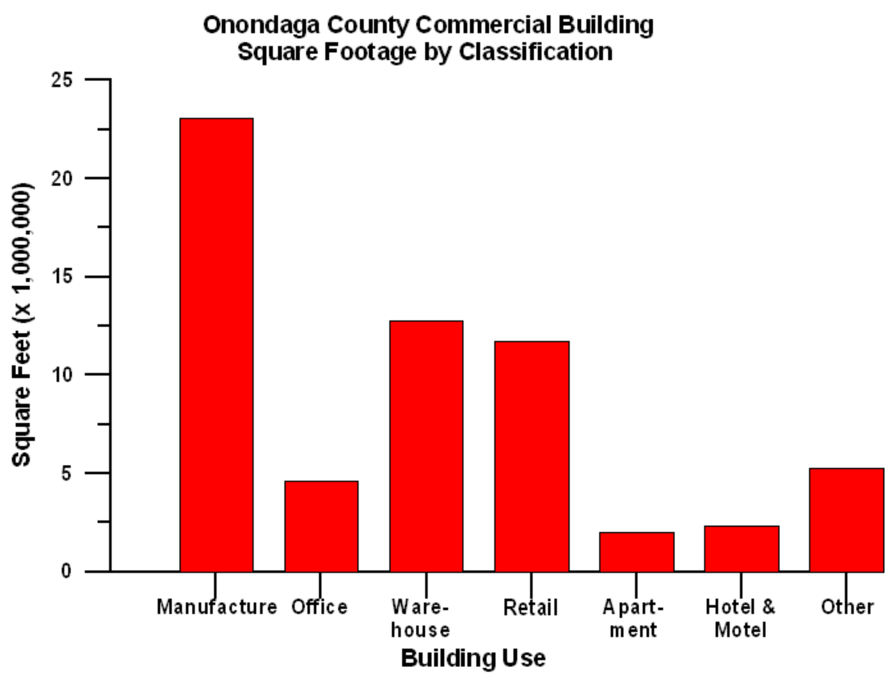


Figure 27-4.Commercial Buildings in the City of Syracuse by Ranges of Square Footage

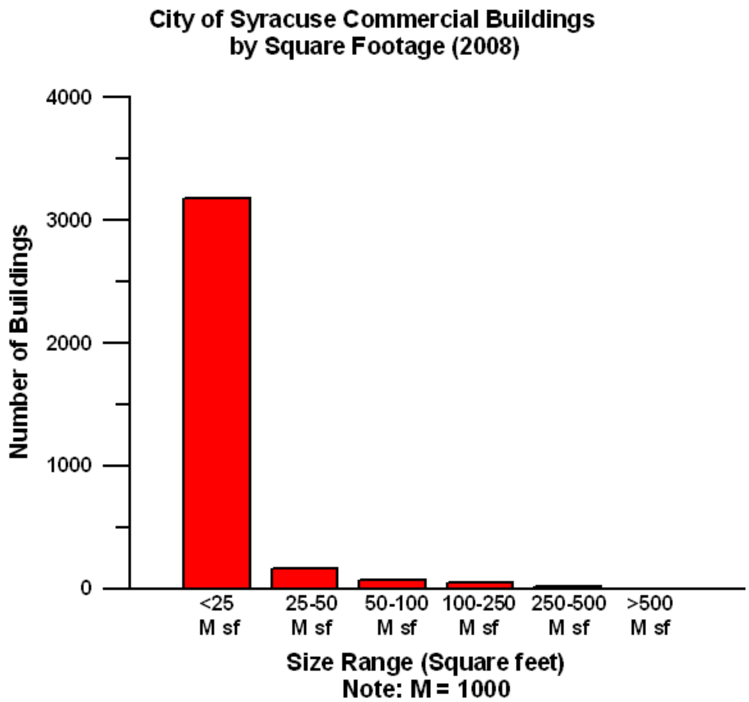


Figure 27-5.Classification of Commercial Buildings in City of Syracuse.

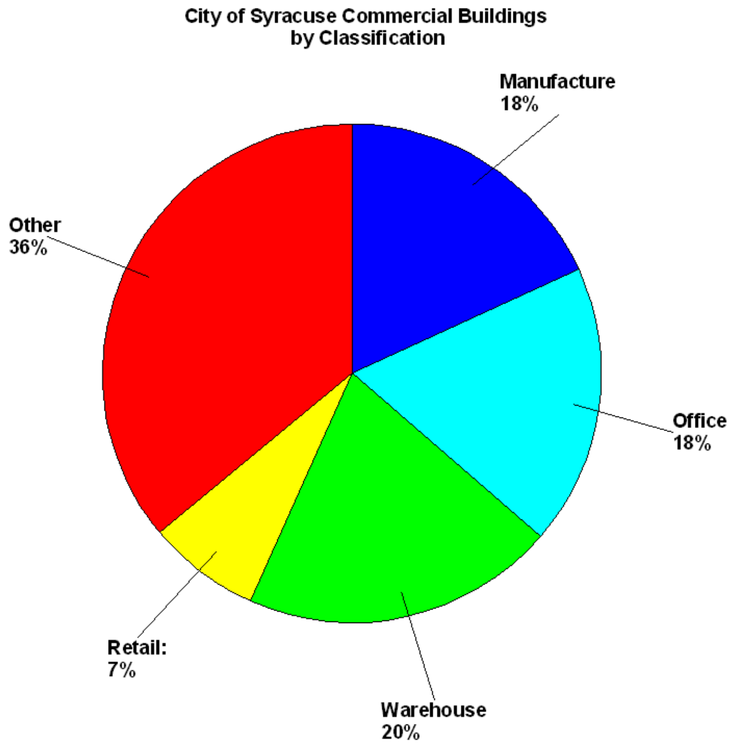
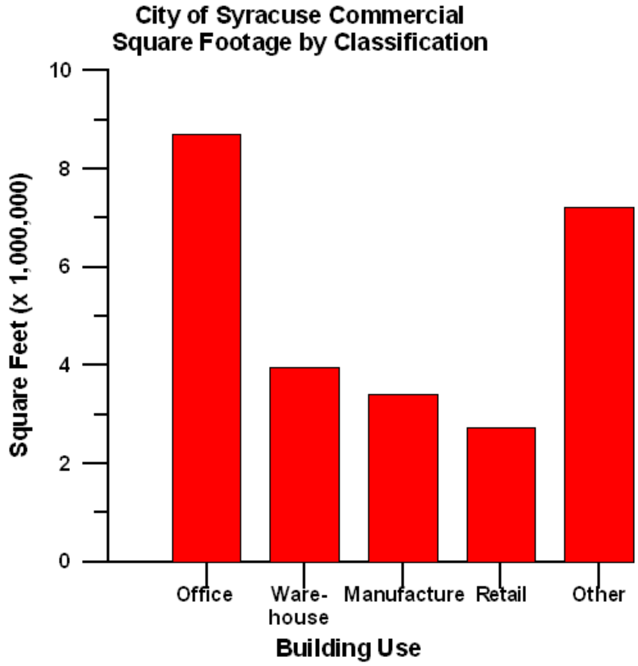


Figure 27-6.Classification and Square Footage of Commercial Buildings in Syracuse.



27.3 Commercial Building Information - Onondaga County

Table 25-1 provides information for commercial buildings in Onondaga County arranged by increasing square footage. It is concievable some of these properties could be NCW customers.

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Gross Square Footage 25,000 - 50,000 S.F.				
Dewitt	Office Bldg.	25,000	Adler	Oliva Holding Co
Dewitt	Office Bldg.	25,000	Collamer	MD3 Holdings LLC
Dewitt	Office Bldg.	25,000	Collamer	Oliva Dev LLC
Dewitt	Warehouse	25,000	Fly	Oliva Properties Co
Geddes	Warehouse	25,000	John Glenn	3545 John Glenn Blvd LLC
Lysander	Auto Dealer	25,017	Burdick St N	Romano Realty LLC
Salina	Apartment	25,056	Vine	Schayes, Adolph
Camillus	Apartment	25,080	W Genesee	Camillus Housing Co Lp
Dewitt	Auto Body	25,100	Corporate	Vault, Julian A
Dewitt	Warehouse	25,200	Corporate	Corporate Drive West LLC

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Dewitt	Warehouse	25,200	Court St	Masterpol, Nicholas J Jr
Camillus	Supermarket	25,200	Milton	Aldi Inc (New York)
Dewitt	Manufacture	25,200	Moore	Weiss, Steven
Dewitt	Apartment	25,380	Thompson	Pandelly Family Ltd
Camillus	Apartment	25,404	Kings Gate West	Kings Gate West
Salina	Auto Body	25,412	Vickery	Huntington Associates L.P.
Dewitt	Truck Terminal	25,450	Schuyler	New Penn Motor Express Inc
Dewitt	Apartment	25,512	Nottingham	The Nottingham Retirement Comm
Dewitt	Manufacture	25,600	Kinne	6666 Kinne LLC
Dewitt	Apartment	25,646	Nottingham	The Nottingham Retirement Comm
Dewitt	Warehouse	25,700	Technology	Technology Enterprises LLC
Dewitt	Warehouse	25,700	Technology	Technology Enterprises LLC
Elbridge	Supermarket	25,831	Main	Elbridge LLC
East Syracuse	Manufacture	25,848	Carr	Bristol-Myers Squibb Co
Dewitt	Warehouse	25,875	Joy	Crossroads J.R.C LLC
Clay	Large Retail	25,956	Buckley	Hafner, Charles
Clay	Warehouse	26,000	Edgecomb	Ulmer Davis Llc
Cicero	Auto Dealer	26,022	Brewerton	Route 11, LLC
Solvay	Att row bldg	26,044	Genesee	2105 West Genesee LLC
Dewitt	Warehouse	26,060	Schuyler	Bellotti, Louis Jr
Dewitt	Warehouse	26,176	Molloy	Gerharz Family Ltd Partnership
Baldwinsville	Motel	26,200	Downer	Baldwinsville Hospitality, LLC
Clay	Large Retail	26,305	Oswego	Hiawatha Plaza Land Dev LLC
Salina	Warehouse	26,308	Vine	Mucci, Ronald L
Dewitt	Manufacture	26,365	Manlius Center	Armstrong Properties LLC
Lysander	Manufacture	26,398	Loop	8265 Loop Rd LLC
Dewitt	Warehouse	26,400	Joy	Pucciarelli, Frank S
Dewitt	Lumber Yard	26,400	Midler Park	G & A Properties LLC
Cicero	Warehouse	26,400	Taft	Cleland Real Estate Group
Salina	Reg'l Shop Ctr.	26,404	Old Liverpool	Huron Liverpool, LLC
Dewitt	Manufacture	26,479	Butternut	Armstrong Properties LLC
Dewitt	1 use small Bldg.	26,500	Corporate	19 Corporate Cir LLC
Salina	Office Bldg.	26,503	S Service	City of Syracuse
Salina	Manufacture	26,543	Court	3496 Court St Syr Props LLC
Salina	Warehouse	26,586	Lemoyne	Bennett, Scott C
Salina	Manufacture	26,595	Lemoyne	Clement Family LP
Salina	Warehouse	26,640	Monarch	Steiglitz Holdings LP
Manlius	Apartment	26,694	Sabre	Academy Place Associates
Dewitt	Reg'l Shop Ctr.	26,728	Erie	Erie Boulevard East Assoc.
Dewitt	Manufacture	26,745	Celi	General Super Plating Co Inc

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Marcellus	Apartment	26,766	South	Braeside, Apts C0
Dewitt	Office Bldg.	26,785	Brittonfield	NYSUT Building Corp
Camillus	Local Shop Ctr	26,852	Milton	Elm Hill Plaza Llc
North Syra-cuse	1 use small Bldg.	26,900	Taft	Smith , Stephen P
Clay	Apartment	26,936	Candlelight	Candlelight Lane Assoc LP
Dewitt	Office Bldg.	26,964	Thompson	Oliva Holding Co
Dewitt	Warehouse	27,000	Corporate	Oliva Holding Co
Dewitt	Warehouse	27,000	Corporate	Oliva Holding Co
Dewitt	1 use small Bldg.	27,000	Corporate	Oliva Holding Co
Baldwinsville	Inn/Lodge	27,000	Syracuse	J&J Enterprises of Central NY
Dewitt	Manufacture	27,060	E Molloy	Industrial Fab
Salina	Office Bldg.	27,074	Metropolitan Pk	Shoenfeld, Martha
Salina	Manufacture	27,166	Monarch	Galaxy Mfg Co Of Cny Inc
Van Buren	Cold Storage	27,177	Walters	National Industrial Portfolio
Jordan	Apartment	27,246	Peru	Jordan Associates IV LP
Salina	Warehouse	27,275	Monarch	Pipines, Stella
Dewitt	Truck Terminal	27,312	Northern	Yellow Transportation Inc
Tully	Auto Body	27,316	Community	Federal Signal Corp
Salina	Manufacture	27,391	Wolf	Cooper Crouse Hinds LLC
Solvay	Apartment	27,396	Woods	Woods Road LLC
Dewitt	Manufacture	27,400	Carrier	Carrier Corporation
Solvay	Cold Storage	27,651	Matthews	Deli-Boy Provisions Inc.
Dewitt	Auto Dealer	27,660	Molloy	Conway, Thomas A
Clay	Lumber Yard	27,700	Henry Clay	Products & Distribution LLC
Manlius	Manufacture	27,731	Fayette	Hollowick Inc
Dewitt	Manufacture	27,731	Thompson	PCI Paper Conversions Inc
Manlius	Apartment	27,744	Seneca	Carriage House East LLC
Onondaga	Prof. Bldg.	27,882	Broad	Community General Hospital, General
East Syracuse	Mini/Whsle SelfSto	27,900	Basile Rowe	Sovran Acquisition Ltd
Solvay	Local Shop Ctr	27,900	Genesee	BDS Realty Assoc
Dewitt	Warehouse	28,000	Corporate	Corporate Drive East LLC
Dewitt	Warehouse	28,000	E Molloy	Oliva Properties Co
Dewitt	Manufacture	28,000	Tarbell	Frel Properties Inc
Dewitt	Apartment	28,032	Nottingham	The Nottingham Retirement Comm
Salina	Auto Dealer	28,100	7th North	Paradis, John T
Salina	Office Bldg	28,160	Elwood Davis	Caring Coalition of CNY
North Syra-cuse	1 use small Bldg.	28,160	Gateway Park	Crossroads Gateway LLC
Dewitt	Warehouse	28,160	Ridings	Thresh Properties LLC

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Clay	Warehouse	28,177	Edgecomb	Mahoney, Joanne G
Salina	Restaurant	28,315	Old Liverpool	Vesta Community Housing
Dewitt	Cold Storage	28,350	Eastern	MAT Properties Inc
Salina	Office Bldg.	28,410	Electronics	549 Electronics Pkwy LLC
Geddes	Motel	28,416	State Fair	Keegan Enterprises
Dewitt	Warehouse	28,453	Schuyler	Food Bank of CNY
Salina	Manufacture	28,476	Wolf	Cooper Crouse Hinds LLC
Geddes	Reg'l Shop Ctr.	28,594	Onondaga	Western Lights Station Inc
Manlius	Manufacture	28,650	Stickley	Onondaga Co IDA
Solvay	Large Retail	28,675	Milton	147 Croly Apts Inc
Dewitt	Manufacture	28,756	Thompson	Bristol-Myers Squibb Co
Dewitt	Office Bldg.	28,800	Molloy	Rodax Enterprises
Dewitt	Manufacture	28,866	Court St	Barnes And Cone Inc
Salina	Manufacture	28,955	Metropolitan Pk	ABS Corporation
Dewitt	1 use small Bldg.	29,020	Frontage	Circle Road Plaza, LLC
Dewitt	Manufacture	29,064	Molloy	JK Wood Properties LLC
Skaneateles	Apartment	29,098	Fennell	Gateway, Apartments
Dewitt	Office Bldg.	29,144	Molloy	Pickard, Kevin M
Van Buren	Truck Terminal	29,224	Van Buren	The Pyle Corporation
Clay	Apartment	29,232	Oswego	Wellington Manor
Dewitt	Truck Terminal	29,240	Thompson	Ruston, Lawrence M
Dewitt	Office Bldg.	29,283	Fly	Kessler, F Philip Jr
Dewitt	Truck Terminal	29,311	Northern	eMerchant LLC
Van Buren	Warehouse	29,376	Crossroads Pk	Harbor Bluffs LLC
Van Buren	Auto Dealer	29,380	Maple	VanWie Chevrolet Inc
Dewitt	Manufacture	29,424	Pickard Dr E	PB & H Molding Corp
Salina	Office Bldg.	29,435	Northern Con-course	One Northern Concourse LLC
Clay	Local Shop Ctr	29,440	Oswego	Kimbrook Route 31 LLC
Clay	Apartment	29,508	Pine Hollow	Byrne Manor Housing
Manlius	Apartment	29,512	Seneca	Carriage House East LLC
Manlius	Apartment	29,562	Sabre	Academy Place Associates
Salina	Manufacture	29,632	Wolf	Cooper Crouse Hinds LLC
Clay	Warehouse	29,650	Morgan	Xto Associates II Llc
Minoa	Apartment	29,680	East	Minoa Housing Co L P
Dewitt	Multi-use Bldg	29,680	Thompson	Oliva Properties Co
Lysander	Prof. Bldg.	29,682	Willett	8276 Willett Parkway LLC
Dewitt	Motel	29,694	Col Eileen Col-lins	Airport Inn
Marcellus	Apartment	29,736	South	Braeside, Apts C0
Dewitt	Warehouse	29,768	Thompson	LBCMT 1999- C2 E Syracuse LLC

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Salina	Warehouse	29,780	Factory & Lem-oyne	Dubnoff, Ira S
Dewitt	Manufacture	29,950	Midler Park	Terrell, Jack E
Geddes	1 use small Bldg.	29,952	State Fair	AK Schmidt LLC
Dewitt	1 use small Bldg.	30,000	Corporate	Oliva Properties Co
Dewitt	Warehouse	30,000	Deere	Frel Properties Inc LLC
Clay	Manufacture	30,000	Executive	JGB Factoring GMBH LLC
Dewitt	Warehouse	30,000	Joy	N Joy Realty LLC
Geddes	Manufacture	30,000	Lakeside	Christou Associates
Clay	Large Retail	30,000	State Route 31	Cor Clay Company LLC
Dewitt	Motel	30,220	Old Collamer	Proximity Holdings Inc
Dewitt	Warehouse	30,390	Deere	Center Circles LLC
Dewitt	Office Bldg.	30,480	Fly	2 + 4 Partnership
Dewitt	Warehouse	30,500	Ellicott	Oliva Properties
Dewitt	Manufacture	30,624	Myers	New York Job Dev Authority
Skaneateles	Lumber Yard	30,694	Fennell	Village Ventures of Skaneatele
Dewitt	Manufacture	30,780	Carrier	Carrier Corporation
Fayetteville	Auto Dealer	30,788	Genesee	NU-540 E. Genesee St. LLC
Dewitt	Warehouse	30,789	Corporate	W W Grainger Inc
Dewitt	Office Bldg.	30,800	Old Collamer	Oliva Holding Co
Clay	Supermarket	30,865	State Route 31	Wegmans Food Markets Inc
Dewitt	Warehouse	31,060	Fisher	Armstrong Holdings LLC
Salina	Motel	31,135	Buckley	Tramz New York Ltd
Onondaga	Office Bldg.	31,250	Onondaga	Onondaga County
Dewitt	Office Bldg.	31,271	Brittonfield	Dairylea Cooperative Inc
Manlius	Motel	31,484	Genesee St E	Craftsman Inn
Salina	Truck Terminal	31,500	Kuhn	Cole Realty Holding Llc
Dewitt	Manufacture	31,590	Eastbourne	Eastbourne Properties LLC
Cicero	Local Shop Ctr.	31,657	Brewerton	Vision Dev Inc
Dewitt	Manufacture	31,680	New Court	L'Hoyroa, Mechon
Dewitt	Lumber Yard	31,720	Galster	Thresh, Eric F
Dewitt	Apartment	31,720	Nottingham	The Nottingham Retirement Comm
Cicero	Reg'l Shop Ctr.	32,000	Circle	T L Marketplace LLC
Dewitt	Warehouse	32,000	Deere	Frel Properties Inc LLC
Cicero	Motel	32,064	Bartel	U M A Hotels Inc
Geddes	Reg'l Shop Ctr.	32,148	Onondaga	Western Lights Station Inc
Clay	Motel	32,161	State Route 31	W2005/Fargo Hotels (Pool C)
Dewitt	Dealer-prod.	32,163	Bridge	Mayflower Elm Holdings LLC
Dewitt	Office Bldg.	32,178	Fair Lakes	6007 Fair Lakes Rd LLC
Salina	Office Bldg.	32,200	Continuum	344 South Warren St. Corp.

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
North Syracuse	Warehouse	32,200	Taft	Diverse Food Products LLC
Dewitt	Prof. Bldg.	32,261	Kirkville	Oliva Properties LLC
East Syracuse	Manufacture	32,344	W Second	Brang, Donald J
Geddes	Apartment	32,364	State Fair	Snowbirds Landing LLC
Dewitt	Manufacture	32,400	Carrier	Carrier Corporation
Dewitt	Warehouse	32,400	New Court	Seneca National Inc
Clay	Office Bldg.	32,422	Henry Clay	HUB Properties Trust
North Syracuse	Warehouse	32,528	Gateway Park	Diverse Food Products LLC
Skaneateles	Manufacture	32,530	State Street	Welch Allyn Inc.
Camillus	Apartment	32,538	Kings Gate West	Kings Gate West
Salina	Manufacture	32,616	Commerce	245 Commerce LLC
Salina	Auto Dealer	32,683	Old Liverpool	Bowen Family Ltd. Partnership
Dewitt	Office Bldg.	32,706	Campuswood	Nocha Group 3 LLC
Camillus	Apartment	32,730	W Genesee	NCR OF CAMILLUS
Dewitt	Lumber Yard	32,772	Manlius Center	84 Lumber Co
East Syracuse	1 use small Bldg.	32,800	Erie	BG DeWitt M & CEC, LLC
Camillus	Apartment	32,868	Eagle	Elm Hill West Apartments
Dewitt	Manufacture	32,886	Collamer	Industrial Fab Corp
Salina	Manufacture	32,980	Buckley	Will & Baumer Inc
Clay	Warehouse	32,984	Buckley	KRSM LLC
Dewitt	Manufacture	33,023	Midler Park	Three Guys Realty LLC
Clay	Local Shop Ctr.	33,044	Oswego	Clay Commons LLC
Onondaga	Manufacture	33,055	Cherry Valley Tpk	Beak & Skiff App Inc
Salina	Motel	33,164	7th North	Om Sai Gayatri Inc.
Dewitt	Warehouse	33,300	Tarbell	MSF Holding LLC
Salina	Warehouse	33,320	Col Eileen Collins	Aero Syracuse, LLC
Geddes	Cold Storage	33,380	State Fair	Deli-Boy Inc
Clay	Warehouse	33,455	Wetzel	Whitacre Engineering Co
Camillus	Auto Body	33,478	W Genesee	Vision Development Inc
Dewitt	Warehouse	33,520	Commerce	PJP Associates
Cicero	Manufacture	33,589	Daedalus	Kadah Properties LLC
Salina	Manufacture	33,600	Buckley	Will & Baumer Inc
Dewitt	Manufacture	33,600	Court St	tMitten Family
Dewitt	Warehouse	33,600	Eastbourne	HSW Partnership
Dewitt	Warehouse	33,600	Ogle	Alpha Jamesville Corp
Clay	Office Bldg.	33,600	Steelway Blvd N	Waste Managemnent of NY LLC

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Camillus	Apartment	33,628	Pegasus	Starlight Estates Apartmts LLC
Clay	Apartment	33,735	Buckley	Loretto Buckley Landing
East Syracuse	Warehouse	33,856	Manlius	Clearwood, Custom
Salina	Apartment	33,885	Kellars	Kellars Lane LLC
Solvay	Large Retail	34,015	Milton	147 Croly Apts Inc
North Syra-cuse	Local Shop Ctr.	34,180	Main	New Plan North LLC
Dewitt	Manufacture	34,200	New Court	GAT Holding Co Inc
Salina	Manufacture	34,440	Buckley	Will & Baumer Inc
Dewitt	Motel	34,522	Baptist	GJ Remainder LLC
Tully	Manufacture	34,572	Route 281	Shafer Charles E.
Salina	Local Shop Ctr.	34,655	Brewerton	Mattydale Commons LLC
Skaneateles	Manufacture	34,663	Jordan	JSkaneateles Falls
Manlius	Apartment	34,680	Seneca	Carriage House East LLC
Onondaga	Supermarket	34,763	Salina	Green, Hills Farm Stores
Salina	Motel	34,783	Transistor	Kevidco LLC
Dewitt	Warehouse	35,008	Creek	Verizon Wireless
Salina	Manufacture	35,076	Lemoyne	Meloon Properties Llc
Salina	Office Bldg.	35,280	Greenfield	215 GP LLC
Baldwinsville	Apartment	35,760	La Madre	Smokey Hollow Housing
Dewitt	Manufacture	35,990	New Venture Gear	Carrier Circle Business Comple
Dewitt	Manufacture	36,000	Solvay Rd	Hanson Aggregates New York Inc
Salina	Warehouse	36,222	Hathaway	Greco, Anthony R
Geddes	Warehouse	36,300	Dwight Park	121 Dwight Park Cir LLC
Salina	Motel	36,352	7th North	Buckley Road Dev Co
East Syracuse	Manufacture	36,377	Thompson	Bristol-Myers Squibb Co
Salina	Local Shop Ctr.	36,404	Brewerton	J & J Desantis Plumbing
Dewitt	Manufacture	36,465	Firestone	Thomas Oberdorfer Pumps Inc
Dewitt	Warehouse	36,542	Fly	The United Development Co
Dewitt	Lite Ind. Mfg.	36,552	Benedict	OCIDA
Skaneateles	Supermarket	36,720	Fennell	Midcourt Bld Corp
Clay	Manufacture	36,750	Executive	JGB Factoring GMBH LLC
Van Buren	Apartment	36,904	Village Blvd S	Country Club Enterprises, LLC
Manlius	Local Shop Ctr.	36,921	Manlius Center	Fremont First Associates LLC
Clay	Prof. Bldg.	36,946	Oswego	Orkin's Clay Medical Center LL
Manlius	Local Shop Ctr.	36,989	Fayette	Manlius Realty LLC
Manlius	Apartment	37,000	Salt Springs	Redfield So Hsg Dev Fund
Dewitt	Warehouse	37,500	Baker	Brown Property Mgmt LLC
Salina	Warehouse	37,537	Continuum	Gallagher Electric Park
Salina	Manufacture	37,550	Buckley	Will & Baumer Inc

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
East Syracuse	Manufacture	37,944	Carr	Bristol-Myers Squibb Co
Dewitt	Lumber Yard	38,000	Midler Park	G & A Properties LLC
Dewitt	Warehouse	38,144	Kinne	Syracuse Union Place LLC
Dewitt	Motel	38,306	Thompson	Onawa Corp
Cicero	Manufacture	38,343	Performance	Onondaga Co Ind Dev Agy
Salina	Reg'l Shop Ctr.	38,349	Northern Lights	Norwill Associates
Clay	Warehouse	38,400	Crossroads Pk	U.R. Best Resort Inc
Dewitt	Manufacture	38,400	Midler	Midler Business Center LLC
Clay	1 use small Bldg.	38,446	Oswego	8512 Route 57 LLC
Dewitt	Manufacture	38,577	Benedict	LMIII Realty LLC
Dewitt	Manufacture	38,595	Burnet	Bristol-Myers Squibb Co
Cicero	Manufacture	38,727	Round Pond	Onondaga Co Ind Dev Agy
Cicero	Manufacture	38,920	Pardee	P Drescher Co Inc
Lysander	Manufacture	38,960	Belgium	Onondaga County
Liverpool	Det row bldg.	38,974	Vine	Village Mall Apartments LLC
Salina	Manufacture	39,360	Commerce	Mcauliffe Associates
Clay	Apartment	39,375	Theodolite	Benchmark Apt. Communities Inc
East Syracuse	Manufacture	39,482	Thompson	Bristol-Myers Squibb Co
East Syracuse	Manufacture	39,596	Thompson	Bristol-Myers Squibb Co
Manlius	Apartment	39,676	Bowman	Colonial Village LLP
Dewitt	Office Bldg.	39,712	Widewaters Pky	Hub Properties Trust
Dewitt	Office Bldg.	39,712	Widewaters Pky	Hub Properties Trust
Salina	Prof. Bldg.	39,714	Northern Con-course	Asset Realty LLC
Dewitt	Office Bldg.	39,745	Northern	Northwood Business Center Asso
Dewitt	Warehouse	40,000	Chrysler	Bronzewood LLC
Dewitt	Warehouse	40,000	Deere	Frel Properties Inc
Dewitt	Office Bldg.	40,000	Kinne	Microwave Filter Co Inc
Dewitt	Warehouse	40,000	Ridings	Alling & Cory
Salina	Office Bldg.	40,328	Electronics	Frst Republic Corp of America
Clay	Warehouse	40,500	Morgan	Supreme Real Estate LLC
Clay	Warehouse	40,500	Steelway Blvd S	550BSA III LLC
Clay	Warehouse	40,500	Steelway Blvd S	Steelway Realty Corp
Dewitt	Office Bldg.	40,625	Brittonfield	Hub Properties Trust
East Syracuse	Manufacture	40,880	Burnet	Bristol-Myers Squibb Co
Dewitt	Warehouse	41,200	Chrysler	Bronzewood Llc
Salina	Office Bldg.	41,292	South Bay	Pomeroy 5404 Associates LLC
Cicero	Prof. Bldg.	41,497	Route 31	Oliva Holding Co
Solvay	Manufacture	41,500	Milton	Haines Samuel
East Syracuse	Manufacture	41,616	Thompson	Bristol-Myers Squibb Co

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Manlius	Manufacture	41,624	Fairground	Hollowick Inc
Dewitt	Warehouse	41,663	Pickard	Bossong, Frederick J
East Syracuse	Manufacture	41,700	Carr	90 Terrace Street LLC
Salina	Manufacture	41,796	Commerce	Commerce Blvd Assoc
Dewitt	Manufacture	41,837	Thompson	PCI Paper Conversions Inc
Salina	Manufacture	41,885	Wolf	Cooper Crouse Hinds LLC
Clay	Manufacture	42,000	Buckley	Richmond Avenue Assoc Inc
Salina	Warehouse	42,000	Col Eileen Collins	Aero Syracuse, LLC
Dewitt	Warehouse	42,000	Deere	Deere Road Developers
LaFayette	Apartment	42,075	Route 20 East	LaFayette Housing Assoc
Clay	Prof. Bldg.	42,110	Buckley	Medical Center Realty LLC
Camillus	Manufacture	42,150	Genesee	Green Leaf Holdings I LLC
East Syracuse	Auto Dealer	42,150	Basile Rowe	Romano Basile Rowe LLC
Onondaga	Apartment	42,698	McDonald	Ahepa 37 Inc
Dewitt	Reg'l Shop Ctr.	42,714	Widewaters Pky	Buffalo DeWitt Associates LLC
Dewitt	Prof. Bldg.	42,732	Widewaters Pkwy	Buffalo Dewitt Associates LLC
Clay	Manufacture	42,800	Morgan	P. Drescher Co., Inc.
Cicero	Warehouse	42,863	Stewart	On Co Ind Dev Ag
Manlius	Apartment	43,026	Manlius-Cazenovia	Suburban Park Dev Assoc LLC
Cicero	Auto Dealer	43,039	Brewerton	Meltzer Enterprises, LLC
Van Buren	Warehouse	43,200	Smokey Hollow	Sysco Food Services
Baldwinsville	Local Shop Ctr.	43,379	Dey	Sedgewick Properties Ass LLC
Clay	Manufacture	43,408	Elwood Davis	M S Kennedy Corp
Salina	Office Bldg.	43,442	Lawrence Rd E	Hub Properties Trust
Salina	Local Shop Ctr.	43,450	Townline	Pemco Group
Dewitt	Warehouse	43,464	Railroad	6800 Townline Rd Partnership
Van Buren	Manufacture	43,539	Willett	Sabre Demolition Corporation
Lysander	Warehouse	43,592	Milton	NU-8255 Willett Parkway, LLC
Camillus	Local Shop Ctr.	43,782	Genesee	Widewaters Milton Ave Comp LLC
Solvay	Local Shop Ctr.	43,824	Route 31	Westvale Plaza
Cicero	Local Shop Ctr.	43,840	Old Collamer	E & E Associates LLC
Dewitt	Motel	43,850	Salina	MBF Dev Co
Onondaga	Local Shop Ctr.	43,932	Nottingham	Syracuse Heights Assoc LLC
Dewitt	Apartment	44,248	Sanders	The Nottingham Retirement Comm
Dewitt	Office Bldg.	44,420	Creek	Aspen Dental Management Inc
Salina	Office Bldg.	44,730	Salina Meadows	Salina Meadows I & III LLC

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Salina	Office Bldg.	44,730	Salina Meadows	Wachovia Trust Co Trust
Clay	Office Bldg.	44,734	Crossroads Pk	1914 Teall Avenue Assoc
Salina	Manufacture	44,750	Electronics	Nys Urban Dev Corp.
Solvay	Apartment	44,864	Russet	NCR of Solvay Housing
Clay	Large Retail	45,000	Route 31	Clay South Development Co LLC
Dewitt	Manufacture	45,060	Round Pond	%R L Hood/Keebler Co, Round Pond Assoc
Dewitt	Office Bldg.	45,077	Kirkville	Galson Realty LLC
Dewitt	Manufacture	45,241	Thompson	6181 Thompson Road LLC
Camillus	Manufacture	45,600	Genesee	Green Leaf Holdings I LLC
Clay	Reg'l Shop Ctr.	45,755	Route 31	Great Northern Spe LLC
Dewitt	Manufacture	45,806	New Venture Gear	New Venture Gear of New York
Dewitt	Hotel	45,876	Old Collamer Rd S	ESA 0504 Inc
Dewitt	Warehouse	45,900	Firestone	Rosemar Associates LLC
Dewitt	Large Retail	45,961	Erie	Benderson, Randall
Dewitt	Office Bldg.	46,088	Enterprise	Starlight Realty LLC
Salina	Auto Dealer	46,166	Old Liverpool	Bowen Family Ltd. Partnership
Camillus	Manufacture	46,787	Genesee	Green Leaf Holdings I LLC
East Syracuse	Manufacture	46,800	Thompson	Bristol-Myers Squibb Co
Clay	Warehouse	47,000	Crossroads Pk	Jenkins, Michele L
Cicero	Manufacture	47,000	Performance	Cleanroom Systems
Salina	Local Shop Ctr.	47,015	Old Liverpool	Cam Plaza LLC
Dewitt	Motel	47,472	Old Collamer	E Syracuse HHP-II LLC
Salina	Motel	47,844	South Bay	Syracuse Airport Express LLC
Solvay	Manufacture	48,000	Boyd	Pass & Seymour Inc
Dewitt	Warehouse	48,000	Fly	OCIDA
Clay	Large Retail	48,000	State Route 31	R & F Clay LLC
Dewitt	Warehouse	48,192	Court St	Haun Third Properties LLC
Manlius	Local Shop Ctr.	48,245	Seneca St W	Ellish Realty LLC
Clay	Warehouse	48,790	Lumber	Verizon New York Inc
Skaneateles	Hotel	48,850	W Genesee	Mirbeau of Skaneateles LP
Clay	Hotel	48,937	Route 31	Nayana Inc.
Geddes	Manufacture	49,025	Long Branch	300 Longbranch Realty Inc
Dewitt	Auto Dealer	49,130	Manlius Center	Tracey Rd Equip Corp
Dewitt	Manufacture	49,188	E Molloy	DCM Holding Corp
Dewitt	Apartment	49,632	Thompson	Pandelly Family Ltd
Dewitt	Office Bldg.	49,722	Towpath	Towpath Holding LLC
Gross Square Footage 50,000 - 100,00 S.F.				

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Dewitt	Warehouse	50,000	Baker	DeWitt Industrial Prop LLC
Dewitt	Manufacture	50,030	Thompson	Hyla, Robert
Dewitt	Manufacture	50,112	Thompson	6181 Thompson Road LLC
Dewitt	Manufacture	50,400	Carrier	Carrier Corporation
Lysander	Manufacture	50,428	Loop	Fluid Power Sales Inc
Van Buren	Motel	50,856	Interstate Island	C I Properties Inc
Cicero	Office Bldg.	50,894	Taft	Notohio, LLC
Van Buren	Hotel	51,030	Winchell	Van Buren Lodging, LLC
Dewitt	Local Shop Ctr.	51,049	Nottingham	Peter, Joseph E
Clay	Warehouse	51,150	Morgan	Gevanthor, Arlene
Dewitt	Warehouse	51,324	Court St	Martino, Mark R
Clay	Prof. Bldg.	51,380	Taft	W Taft Rd Associates
Salina	Motel	51,576	Elwood Davis	New England Realty
Dewitt	Warehouse	51,584	Kirkville	The Raymond Corp
Cicero	Manufacture	51,625	Guy Young	Schneider Fam Ltd Ptnshp
Dewitt	Hotel	51,683	Baptist	Tramz NY LLC
Manlius	Apartment	51,730	Manlius-Cazen-ovia	Suburban Park Dev Assoc LLC
Manlius	Local Shop Ctr.	52,008	Burdick	Onondaga Co IDA
Dewitt	Manufacture	52,022	New Venture Gear	New Venture Gear Inc
Dewitt	Office Bldg.	52,380	Brooklawn Pkwy	Pemco Brooklawn LLC
Onondaga	Office Bldg.	52,430	Skytop	Syracuse, University
Skaneateles	Manufacture	52,650	Visions	Onondaga Cty Ind Dev Agency
Dewitt	Apartment	52,694	Nottingham	The Nottingham Retirement Comm
Marcellus	Warehouse	52,726	North	Crown Mill Restoration Dev
Van Buren	Local Shop Ctr	52,838	State Fair	E F Thresh Inc
Clay	Manufacture	52,900	Crown	Arnold Bay Farms Inc
Dewitt	Manufacture	53,988	Thompson	PCI Paper Conversions Inc
Clay	Supermarket	54,050	State Route 31	Wegmans Food Markets Inc
Salina	Office Bldg.	54,126	Salina Meadows	Wachovia Trust Co Trust
East Syracuse	Manufacture	54,592	Thompson	Bristol-Myers Squibb Co
Clay	Warehouse	54,750	Crossroads Pk	Rescue Mission Alliance of Syr, NY Inc
Clay	Manufacture	54,944	Henry Clay	7327 Henry Clay Blvd
Dewitt	1 use small bldg	55,000	Enterprise	Enterprise Ltd Partnership
East Syracuse	Manufacture	55,025	Thompson	Bristol-Myers Squibb Co
Camillus	Prof. Bldg.	55,243	W Genesee	Medical Center West LLC
Geddes	Manufacture	55,442	State Fair	Crucible Development Corp.
Dewitt	Warehouse	55,600	Commerce	Masterpol Family LLC
Clay	Manufacture	55,840	Crossroads Pk	MBC Enterprises LLC

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Fayetteville	Manufacture	55,880	Clinton	NU-400 Clinton St LLC
Dewitt	Manufacture	56,064	Carrier	Carrier Corporation
Cicero	Local Shop Ctr.	56,075	Bartel	Tisdell, Robert L
Onondaga	Local Shop Ctr.	56,359	Salina	Syracuse Heights Assoc LLC
Elbridge	Manufacture	56,384	Jordan	Welch Allyn Inc
Dewitt	Local Shop Ctr.	56,416	Erie Blvd E	Dewitt Commercial Assoc
Dewitt	Manufacture	56,438	Lepage	CES LLC
Camillus	Reg'l Shop Ctr.	56,520	W Genesee	BUFFALO MAIN ST LLC
Dewitt	Manufacture	56,550	Kirkville	Anaren Microwave Inc
Cicero	Warehouse	56,562	Taft	Riccelli, Enterprises
Liverpool	Manufacture	56,654	Oswego	OCIDA
Dewitt	MiniWhseSelfSto	56,836	Kinne	SS DeWitt LLC
Geddes	Local Shop Ctr	56,930	Genesee	Fairmount Center Inc
Salina	Manufacture	57,200	Electronics	Nys Urban Dev Corp.
Salina	Office Bldg.	57,723	7th North	The State Insurance Fund
Clay	Large Retail	57,858	Buckley	Hafner, Charles
Clay	Warehouse	58,110	Crossroads Pk	National Grid
Salina	Warehouse	58,216	Kuhn	The Leigh Corp.
Dewitt	Supermarket	58,235	James	Wegmans Enterprises Inc
East Syracuse	Local Shop Ctr.	58,430	Manlius Center	Manlius Center Rd Assoc LLC
Dewitt	Warehouse	58,496	Thompson	Higbee Realty DeWitt LLC
Clay	Warehouse	58,512	Crossroads Pk	Dement Realty LLC
Clay	Office Bldg.	58,604	Crossroads Pk	U.R. Best Resort Inc
Geddes	Warehouse	58,717	Dwight Park	Gatsby, Ind Real Estate
Manlius	Supermarket	58,729	Seneca St W	DB Real Estate of Manlius
North Syra-cuse	Local Shop Ctr	59,085	Main	Bear Station Inc
Dewitt	Manufacture	59,270	New Court	American Linen Supply Co
Dewitt	Motel	59,343	New Venture Gear	Cresthill Suites Syracuse LLC
Dewitt	Manufacture	59,500	Carrier	Carrier Corporation
Dewitt	Manufacture	60,000	Court St	Crossroads J.R.C LLC
Dewitt	Warehouse	60,000	Deere	Syracuse Deere Rd
Dewitt	Warehouse	60,000	Ellicott	FMV Associates
Dewitt	Office Bldg.	60,000	Tarbell	Midler Court Realty Inc
Cicero	Warehouse	60,000	Totman	Cleland Real Estate Group
Dewitt	Manufacture	60,000	Townline	Townline Realty Llc
Skaneateles	Manufacture	60,000	Visions	Onondaga Cty Ind Dev Agency
Cicero	Local Shop Ctr.	60,300	Frontage	Circle Rd Group LLC
Cicero	Local Shop Ctr.	60,300	Frontage	Circle Road Plaza, LLC
Dewitt	Warehouse	60,400	Joy	ABC Properties of Syracuse LLC

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Salina	Warehouse	60,625	Vine	Ground Water Industries, Inc.
Clay	Large Retail	60,695	State Route 31	Cor Route 31 Co Llc
Onondaga	Manufacture	60,800	Nixon Park	Nixon Gear, LLC
Clay	Large Retail	60,901	Oswego	Berg, Investors
Dewitt	Hotel	60,903	Fair Lakes	Exit 35 Hotel Partners LLC
Van Buren	Reg'l Shop Ctr	61,082	Downer St	River Mall Station, Inc
Van Buren	Dealer-prod.	61,204	Interstate Island	M D Meyers Properties LLC
Clay	Warehouse	61,250	Crown	Christou Associates
Van Buren	Warehouse	61,311	Warners	Onondaga County Indus
Manlius	Manufacture	61,350	Fairground	Hollowick Inc
East Syracuse	Auto Dealer	61,790	Chevy	E Syracuse Sales Co Inc
Dewitt	Lumber Yard	62,246	Midler Park	Reserve, Supply
Dewitt	Manufacture	62,278	Lepage	CES LLC
Dewitt	Office Bldg.	62,764	Towpath	Towpath Holding LLC
Clay	Prof. Bldg.	62,800	Taft	Medical Center Realty LLC
Solvay	Manufacture	63,030	Industrial	Onondaga County Ind
Dewitt	Manufacture	63,200	Fly	Murphy james A
Manlius	Supermarket	63,349	Towne	Onondaga Co IDA
Dewitt	Apartment	63,527	Genesee	Jewish Home of CNY
Dewitt	Warehouse	63,584	Court St	Ventre, Martin A
Dewitt	Warehouse	63,600	Baker	101 Danzig St Equities LLC
Dewitt	Motel	63,900	Thompson	Tramz NY Syracuse Llc
Clay	Warehouse	64,000	Steelway Blvd N	550BSA III LLC
Van Buren	Cold Storage	64,000	Warners	SYSCO Food Services
Dewitt	Office Bldg.	64,058	Court St	Road Runner Holdco LLC
Dewitt	Office Bldg.	64,476	Widewaters Pkwy	Hub Properties Trust
Dewitt	Office Bldg.	64,800	Widewaters Pkwy	Principal Comm Accept LLC
Salina	Motel	64,992	South Bay	Syracuse Airport Suite L
Cicero	Large Retail	65,000	Carmenica	WK Gander LLC
Clay	Reg'l Shop Ctr.	65,000	State Route 31	Great Northern Spe LLC
Cicero	Manufacture	65,000	William Barry	GB107 Syracuse NY LLC
Salina	Office Bldg.	65,414	Salina Meadows	Hub Properties Trust
Salina		65,844	7th North	Etna Development Co
Dewitt	Office Bldg.	65,916	Widewaters Pky	Hub Properties Trust
Cicero	Reg'l Shop Ctr.	65,916	Circle	T L Marketplace LLC
Dewitt	Office Bldg.	66,248	Widewaters Pky	Hub Properties Trust
Salina	Manufacture	66,318	Buckley	IT Hospitality Inc.
Onondaga	Apartment	67,520	Velasko	Als-Venture I Inc
Salina	Manufacture	67,523	Wolf	Cooper Crouse Hinds LLC

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Dewitt	Local Shop Ctr.	67,526	Erie Blvd E	Dewitt Commercial Assoc
Dewitt	Manufacture	67,638	Thompson	Bristol-Myers Squibb Co
Geddes	Supermarket	67,638	Genesee	Wegmans Food Market Inc
Dewitt	Office Bldg.	68,478	Brittonfield	Buckley Road Properties Inc
Clay	Supermarket	68,500	State Route 31	Cor Route 31 Company LLC
Dewitt	Warehouse	68,600	Court St	John Deere Co
Dewitt	Warehouse	69,000	Deere	Syracuse Deere Rd
Cicero	Supermarket	69,002	Circle	T-L Marketplace LLC
Manlius	Apartment	69,369	Seneca	Carriage House East LLC
Camillus	Local Shop Ct	69,514	W Genesee	4119 Syracuse Holding LLC
Salina	Apartment	69,592	Elbow	Pitcher Hill Housing Dev. Fund
Salina	Office Bldg.	69,904	Buckley	O'Neill Intermediary LLC
Dewitt	High tech Mfg.	69,910	Collamer Crossings	OCIDA
Salina	Warehouse	70,075	Commerce	OCIDA
Camillus	Apartment	70,092	Eagle	Elm Hill West Apartments
North Syra-cuse	Local Shop Ctr.	70,420	Main	New Plan North LLC
Dewitt	Large Retail	70,518	Erie	DeWitt Comm Assoc Ltd Partners
Dewitt	Office Bldg.	70,868	Widewaters	Hub Properties Trust
Dewitt	Warehouse	70,898	Ridings	Natural Chemistry Inc
Dewitt	Office Bldg.	71,269	Campuswood	American De/spe 2 Llc
East Syracuse	Manufacture	71,454	Thompson	Bristol-Myers Squibb Co
Dewitt	Local Shop Ctr.	71,906	Erie	Erie Blvd Realty Co
Dewitt	Office Bldg.	72,000	Molloy	Rodax Enterprises
Camillus	Warehouse	72,768	Bennett	Emerald Manag Grp LLC
Cicero	Local Shop Ctr.	72,914	Route 31	New Plan North LLC
Van Buren	Multi-Use Bldg	73,730	Interstate Island	Plainville Farms LLC
Skaneateles	Manufacture	73,820	Visions	Vision Drive 1031 DST
Clay	Warehouse	73,910	Buckley	KRSM LLC
Salina	Manufacture	74,064	Needle	Sulzle B G Inc
Salina	Manufacture	74,596	Wolf	Cooper Crouse Hinds LLC
Van Buren	Truck Terminal	74,942	Van Buren	Fedex Ground Pkg Sys Inc
Dewitt	Warehouse	75,000	Deere	Syracuse Deere Rd
Clay	Large Retail	75,000	State Route 31	R & F Clay LLC
Salina	Office Bldg.	75,204	Greenfield	The Edgewater Salina Co
Clay	Local Shop Ctr.	76,078	Oswego	Kimbrook Route 31 LLC
Salina	Manufacture	76,152	Wolf	Cooper Crouse Hinds LLC
Dewitt	Warehouse	76,504	Midler	Genuine Parts Co
Cicero	Supermarket	77,093	Brewerton	Widewaters Route 11

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Dewitt	Manufacture	77,250	Lepage	CES LLC
Cicero	Local Shop Ctr.	77,560	Frontage	Circle Rd Group LLC
Cicero	Local Shop Ctr.	77,560	Frontage	Circle Road Plaza, LLC
Dewitt	Cold Storage	77,828	Molloy	Shalco Properties Inc
Salina	Office Bldg.	78,203	Col Eileen Col-lins	C & S Engineers Inc
Van Buren	Warehouse	78,384	Warners	Onondaga County Indus
Salina	Office Bldg.	78,656	Elwood Davis	Ambani Realty Inc
Clay	Office Bldg	79,004	Taft	Ocida
Skaneateles	Manufacture	79,125	State Street	Welch Allyn, Inc.
Camillu	Reg'l Shop Ctr.	79,135	W Genesee	BUFFALO MAIN ST LLC
Geddes	Motel	79,268	Farrell	M & B Sons LLC
Dewitt	Manufacture	79,505	Kinne	Syracuse Union Place LLC
Geddes	Reg'l Shop Ctr.	79,676	Onondaga	Western Lights Station Inc
Dewitt	Manufacture	80,109	Thompson	Wozniczka , John P Jr
Clay	Retail Service	80,192	State Route 31	Adcor Realty Corp
Clay	Large Retail	80,340	Oswego	Galileo Apollo IV SUB LLC
Salina	Office Bldg.	80,910	Elwood Davis	Thruway Court Tallahassee LLC
Dewitt	Warehouse	81,225	Chrysler	Bronzewood Llc
Salina	Manufacture	81,400	Electronics	Nys Urban Dev Corp.
Salina	Manufacture	81,400	Electronics	Nys Urban Dev Corp.
Salina	Motel	81,580	Buckley	Tramz New York Ltd
Clay	Warehouse	81,750	Steelway Blvd S	550BSA III LLC
Clay	Warehouse	81,750	Steelway Blvd S	Steelway Realty Corp
Salina	Warehouse	82,071	Metropolitan Pk	JGB Factoring GMBH, LLC
East Syracuse	Manufacture	82,332	Thompson	Bristol-Myers Squibb Co
Dewitt	Warehouse	82,530	Thompson	Coolidge Dewitt Llc
Dewitt	Warehouse	83,200	Deere	G & A Properties LLC
Salina	Hotel	83,239	Buckley	Syramada Hotel Corporation
Clay	Warehouse	84,000	Crossroads Pk	JGH Properties LLC
Clay	Restaurant	84,000	State Route 31	Route 31 Associates
Salina	Motel	84,190	7th North	Maplewood Inn LLC
Clay	Apartment	84,324	Janus Park	Parkrose Estates Retirement
Geddes	Manufacture	84,736	State Fair	Crucible Development Corp.
Dewitt	Warehouse	84,800	Court St	Haun Third Properties LLC
Clay	Apartment	84,819	Henry Clay	Norstar Apts Inc
Dewitt	Manufacture	84,882	Thompson	Thompson Corners LLC
Onondaga	Warehouse	84,976	Jamesville	Syracuse University
Clay	Reg'l Shop Ctr	85,000	State Route 31	Great Northern Spe LLC
Clay	Local Shop Ctr.	85,369	Oswego	Wegmans Enterprises Inc

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Clay	Warehouse	85,974	Henry Clay	Fays Drug Co Inc
Dewitt	Motel	86,675	Yorktown	MBF Development Co
Skaneateles	Manufacture	87,464	Jordan	Welch Allyn, Inc
Salina	Warehouse	87,731	Kuhn	Cole Realty Holding Llc
Clay	Large Retail	88,420	State Route 31	Cor Clay Company Llc
Clay	Local Shop Ctr.	89,236	Oswego	Holihan, John H
Cicero	Truck Terminal	89,712	Running Ridge	CalEast Nat City Stations LLC
Clay	Supermarket	90,400	State Route 31	Wegmans Food Markets Inc
Manlius	Reg'l Shop Ctr	90,448	Towne	Cor Route 5 Company LLC
Dewitt	Office Bldg.	90,505	Route 298	Merrem Properties LLC
Van Buren	Reg'l Shop Ctr.	90,858	Downer St	River Mall Station, Inc
Salina	Reg'l Shop Ctr	91,936	Northern Lights	Norwill Associates
Dewitt	Office Bldg.	92,538	Sanders Creek	OCIDA
Dewitt	Office Bldg.	92,745	Widewaters Pky	Hub Properties Trust
Salina	Local Shop Ctr	92,796	Brewerton	Mattydale Commons LLC
Clay	Warehouse	93,600	Henry Clay	Eagle Comtronics Inc
Dewitt	Office Bldg.	94,924	Campuswood	American De/spe 2 LLC
Clay	Local Shop Ctr.	95,574	Oswego	Wegmans Enterprises Inc
Clay	Warehouse	96,000	Steelway Blvd N	550BSA III LLC
Clay	Warehouse	96,078	Steelway Blvd S	4550 Steelway Boulevard LLC
Salina	Office Bldg.	96,084	Plainfield	Salina Meadows I & III LLC
Clay	Local Shop Ctr.	96,653	Brewerton	Syracuse Windsor Land LLC
Dewitt	Manufacture	97,760	Molloy	Mezzalingua Realty Co LLC
Cicero	Motor Veh. Serv.	98,497	Circle	JJK Development LLC
Dewitt	Warehouse	99,192	Fly	Spirit
Clay	Reg'l Shop Ctr.	99,950	State Route 31	Great Northern Spe LLC
Gross Square Footage 100,000 - 200,00 S.F.				
Dewitt	Warehouse	100,000	Enterprise	716 E Washington St Const Corp
Dewitt	Manufacture	100,000	Tarbell	Frel Properties Inc
Lysander	Warehouse	100,000	W Entry	Swanson Radisson GS Co LLC
Dewitt	Warehouse	100,076	Tarbell	Midler Court Realty Inc
Clay	Warehouse	101,780	Edgecomb	Onondaga County
Clay	Warehouse	101,780	Edgecomb	Onondaga County
Clay	Warehouse	102,535	Morgan	Dot Foods Inc
North Syra-cuse	Large Retail	102,580	Main	M Goldberg & Sons Syr Inc
Clay	Warehouse	103,050	Morgan	American Granby Inc
Lysander	Warehouse	105,220	Brundage	Swanson Radisson Co Llc
East Syracuse	Manufacture	105,244	Thompson	Bristol-Myers Squibb Co
Dewitt	Manufacture	105,600	Wavel	Iron Mountain Records

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Dewitt	Manufacture	106,100	New Venture Gear	New Venture Gear of New York
Dewitt	Manufacture	107,665	Kirkville	Anaren Microwave Inc
Dewitt	Manufacture	108,127	Thompson	Metalico Syracuse Realty Inc
Geddes	Manufacture	108,137	State Fair	Crucible Development Corp.
Salina	Large Retail	108,480	Northern Lights	Norwill Associates
Geddes	Manufacture	109,175	State Fair	Crucible Development Corp.
Dewitt	Warehouse	109,440	Manlius Center	Butternut Manlius LLC
Clay	Warehouse	110,250	Crossroads Pk	J & S Leasing Co
Cicero	Large Retail	110,428	Brewerton	Toped Development LLC
Clay	Local Shop Ctr	110,443	Oswego	Hiawatha Plaza Assoc Llc
Salina	Manufacture	110,500	Electronics	Nys Urban Dev Corp.
Dewitt	Office Bldg.	110,811	Fair Lakes	Pioneer Cable Partners LLC
Solvay	Local Shop Ctr	111,056	Genesee	Westvale Plaza
Clay	Warehouse	112,000	Henry Clay	Ruhle & Kerr Assoc
Clay	Manufacture	112,784	Edgecomb	Onon Cty Ind Dev Agency
Clay	Warehouse	113,135	Morgan	Onondaga County
Skaneateles	Manufacture	113,700	State Street	Welch Allyn, Inc.
Camillus	Large Retail	114,396	Milton	HD, Dev of Maryland Inc
Dewitt	Large Retail	115,122	Erie	Super Intermediateco LLC
Manlius	Local Shop Ctr	115,143	Burdick St N	Onondaga Co IDA
Geddes	Manufacture	115,211	State Fair	Crucible Development Corp.
Dewitt	Manufacture	115,300	Molloy	Rita Jacobs Trust
Clay	Large Retail	115,660	State Route 31	Natick NY 1992 Realty Cor
East Syracuse	Large Retail	115,893	Chevy	BJS Syracuse Tardif Trust LLC
Clay	Large Retail	115,908	State Route 31	Wal-Mart Real Estate Business
Dewitt	Reg'l Shop Ctr	116,224	Erie	Erie Boulevard East Assoc.
Dewitt	Large Retail	116,338	Genesee	Wegmans Food Markets Inc
Dewitt	Office Bldg.	116,580	Brittonfield	Buckley Road Properties Inc
Cicero	Auto Dealer	117,207	Circle	RLB Development LLC
Clay	Warehouse	117,515	Edgecomb	Pioneer Warehouse Asso
Geddes	Warehouse	117,740	Farrell	Coca-Cola Bottling Co
Dewitt	Warehouse	119,880	Firestone	Marcus Rose Realty Llc
Dewitt	Motel	120,245	Old Collamer Rd S	Tramz New York Ltd Lp
Jordan	Manufacture	121,632	Beaver	Omega Wire Inc
Salina	Manufacture	121,800	Electronics	Nys Urban Dev Corp.
Clay	Manufacture	121,810	Morgan	P. Drescher Co., Inc.
East Syracuse	Large Retail	124,312	Basile Rowe	Wal-Mart Real Estate Business
Dewitt	Reg'l Shop Ctr.	124,508	Agway	May Dept Stores
Dewitt	Manufacture	124,838	Technology	Leybold Inficon Inc

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Cicero	Retail Service	124,911	Brewerton	Target Corp T2295
Clay	Large Retail	125,614	State Route 31	Target Corporation
Clay	Local Shop Ctr	126,105	State Route 31	Marketfair Fee LLC
Camillus	Large Retail	127,391	W Genesee	Target Corporation
East Syracuse	Manufacture	127,640	Thompson	Bristol-Myers Squibb Co
Salina	Manufacture	127,768	Wolf	Cooper Crouse Hinds LLC
Manlius	Local Shop Ctr	128,851	Burdick	Onondaga Co IDA
Cicero	Large Retail	130,659	Circle	Lowes Home Centers Inc
Salina	Manufacture	131,925	Lemoyne	Bresky Associates
Dewitt	Large Retail	132,450	Bridge	Bridge Street Ltd
Geddes	Manufacture	133,444	State Fair	Crucible Development Corp.
Dewitt	Reg'l Shop Ctr.	134,160	Erie Blvd E	Sears Roebuck & Co
Dewitt	Warehouse	134,400	E Molloy	Cardinal Health 411 Inc
Solvay	Manufacture	134,990	Milton	Landis Plastics
Clay	Local Shop Ctr	135,068	Oswego	Galileo Apollo IV SUB LLC
Clay	Large Retail	135,552	State Route 31	HD Development of Maryland I
Clay	Large Retail	137,209	State Route 31	Sam's Real Estate Business
Dewitt	Warehouse	137,788	Court St	John Deere Co
Fayetteville	Manufacture	138,183	Genesee	O'Brien & Gere Tech Svc Inc
Camillus	Reg'l Shop Ctr	138,735	W Genesee	Buffalo Main St LLC
Clay	Manufacture	138,900	Morgan	Onondaga County
Salina	Manufacture	140,612	Old Liverpool	Water St Assoc LLC
Lysander	Manufacture	140,700	McLane	Onondaga County
Tully	Cold Storage	140,712	Route 281	Aldi Inc
Dewitt	Supermarket	140,990	Genesee	Wegmans Food Markets Inc
Clay	Manufacture	144,672	Steelway Blvd S	Packaging Corp of America
Solvay	Manufacture	144,770	Milton	Frazer & Jones
Solvay	Manufacture	145,300	Boyd	Pass & Seymour Inc
Salina	Reg'l Shop Ctr.	146,958	Northern Lights	Norwill Associates
Clay	Large Retail	147,396	State Route 31	Sears Roebuck & Co
Solvay	Manufacture	148,000	Industrial	Onondaga County Ind
Geddes	Manufacture	148,296	State Fair	Crucible Development Corp.
Solvay	Manufacture	148,888	Industrial	Onondaga County Ind
Lysander	Warehouse	150,000	W Entry	Swanson Radisson GS Co LLC
Geddes	Cold Storage	150,353	Farrell	Art Mortgage Borrower Propco
Clay	Warehouse	150,400	Buckley	Fay's Drug Co Inc Co
Salina	Manufacture	155,469	Court	Libbey Inc.
Dewitt	Manufacture	156,965	Thompson	Telesector Res Group Inc
Dewitt	Manufacture	157,264	Carrier	Carrier Corporation
Clay	Warehouse	160,000	Steelway Blvd S	Ironwood Llc

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Clay	Manufacture	161,500	Henry Clay	Cambridge Capital Corporation
Geddes	Manufacture	162,920	Farrell	Syroco Inc
Geddes	Warehouse	163,725	Farrell	Art Mortgage Borrower Propco
Clay	Warehouse	165,600	Dey	Northland, Industrial
Dewitt	Hotel	165,954	Route 298	W2005 WYN Hotels, L.P.
Salina	Warehouse	168,470	Monarch	Dot Foods Inc
Dewitt	Hotel	169,511	Old Collamer	Ashford Syracuse LP
Lysander	Manufacture	169,829	Sixty	Sixty Road Assoc.
Clay	Warehouse	172,800	Morgan	Onondaga County
Geddes	Manufacture	176,324	State Fair	Crucible Development Corp.
Dewitt	Warehouse	176,998	Court St	Cavallaro Foods LLC Series 2
Salina	Hotel	177,962	Electronics	First Republic Corp of America
Onondaga	Parking Garage	178,750	Broad	Community, General
Clay	Local Shop Ctr	179,710	Taft	Wegmans Food Markets Inc
Dewitt	Manufacture	179,725	Carrier	Carrier Corporation
Onondaga	Parking Garage	180,000	Broad	Community, General
Clay	Large Retail	182,933	State Route 31	Clay South Development Co LLC
Salina	Manufacture	185,934	Wolf	Cooper Crouse Hinds LLC
Dewitt	Manufacture	186,540	Carrier	Carrier Corporation
Salina	Reg'l Shop Ctr.	188,644	Shop City	Shop City PW/LB LLC
Dewitt	Manufacture	192,000	Kinne	6666 Kinne LLC
Clay	Manufacture	196,460	Morgan	TDJ Properties LLC
Dewitt	Manufacture	197,464	Thompson	Telesector Res Group Inc
Dewitt	Reg'l Shop Ctr.	198,086	Erie	Buffalo Dewitt Assoc LLC
Gross Square Footage 200,000 - 500,00 S.F.				
Cicero	Large Retail	203,948	Brewerton	Wal-Mart Property Tax Dept
Camillus	Large Retail	205,018	W Genesee	Buffalo Main St LLC
Van Buren	Manufacture	205,066	State Fair	Syroco, Inc.
Dewitt	Warehouse	206,807	Northern	Bt-Newyo LLC
Dewitt	Office Building	207,675	Butternut	NU-333 Butternut Dr LLC
Baldwinsville	Manufacture	210,000	Boyd	Pass & Seymour Inc
Dewitt	Manufacture	210,958	Thompson	Wre Properties Llc
Solvay	Reg'l Shop Ctr.	213,500	Downer	Crossroads TMC LLC
Salina	Manufacture	215,700	Electronics	Nys Urban Dev Corp.
Van Buren	Cold Storage	230,440	Walters	National Industrial Portfolio
Cicero	Manufacture	238,308	Pardee	Clinton's Ditch Coop Co Inc
Dewitt	Manufacture	245,763	New Venture Gear	Carrier Circle Business Comple
Dewitt	Warehouse	246,927	Thompson	Carrier Circle Business Comple
Geddes	Warehouse	247,375	Farrell	Art Mortgage Borrower Propco

Table 27-1.Commercial Buildings in Onondaga County

Location (Town)	Use	Square footage	Street Name	Owner
Lysander	Manufacture	247,864	McLane	Onondaga County
Salina	Warehouse	250,509	Court	Syracuse Property Partners LLC
Camillus	Manufacture	254,436	Southern	Onondaga Cty Ind Dev Agency
Lysander	Manufacture	256,200	McLane	Onondaga County
Dewitt	Warehouse	257,680	Deere	B&B Family Limited Partnership
Camillus	Reg'l Shop Ctr.	265,834	Genesee	Benderson Dev. Com. Inc.
Salina	Manufacture	267,424	Electronics	Nys Urban Dev Corp.
Dewitt	Warehouse	285,000	Ogle	Alpha Jamesville Corp
Geddes	Manufacture	317,400	Farrell	Syroco Inc
Lysander	Warehouse	353,260	McLane	Onondaga County
Clay	Warehouse	358,400	Steelway Blvd N	550BSA III LLC
Van Buren	Manufacture	358,826	State Fair	Syroco, Inc.
Cicero	Office Building	363,000	Taft	Notohio, LLC
Tully	Cold Storage	363,010	Route 281	Aldi Inc
Manlius	Manufacture	374,362	Stickley	Onondaga Co IDA
Dewitt	Manufacture	398,610	New Venture Gear	New Venture Gear Inc
Dewitt	Reg'l Shop Ctr.	398,946	Erie	Shoppingtown Mall LLC
Cicero	Auto Dealer	409,718	Circle	RLB Development LLC
Salina	Manufacture	423,770	Electronics	Nys Urban Dev Corp.
Cicero	Reg'l Shop Ctr.	429,789	Circle	T L Marketplace LLC
Salina	Manufacture	439,943	Court	Libbey Inc.
Gross Square Footage > 500,000 S.F.				
Geddes	Warehouse	515,918	Van Vleck	National Industrial Portfolio
Clay	Reg'l Shop Ctr.	556,594	State Route 31	Great Northern Spe LLC
Clay	Warehouse	564,108	Henry Clay	Fays Drug Co Inc
Clay	Warehouse	585,613	Morgan	Onondaga County
Dewitt	Manufacture	664,500	Carrier	Carrier Corporation
Dewitt	Manufacture	750,000	Carrier	Carrier Corporation
Salina	Manufacture	775,700	General Motors	General Motors Corp
Dewitt	Manufacture	834,016	Carrier	Carrier Corporation
Dewitt	Reg'l Shop Ctr.	876,645	Erie	Shoppingtown Mall LLC
Dewitt	Manufacture	1,069,583	New Venture Gear	New Venture Gear Inc
Lysander	Manufacture	1,585,000	Belgium	Onondaga County

Table 27-2.Commercial Buildings in the City of Syracuse

Owner	Use	Square Footage	Street(s)
Gross Square Footage 25,000 - 50,000 S.F.			
Crouse Health Hosptl Inc	Det. Row Bldg.	25,056	Crouse Ave S
Lindsley, Richard W	Fuel Store&Dist	25,088	Genant Dr & Clinton St N
Krull Duane M Rvcbl Trust	Warehouse	25,179	Erie Blvd W & Liberty
Byer Alan I Trust	Auto Dealer	25,280	Genesee St W To Dewey
Dunk & Bright Holding Inc	Det. Row Bldg.	25,328	Salina St S & Brighton Av
Friedfertig, Neal N	Att. Row Building	25,404	Warren St S & Jefferson S
Business, Venture Assoc	Prof. Bldg	25,512	Genesee St E & Crouse
Wolcott, Robert C	Warehouse	25,542	Belden Ave W & Van Rensse-lear
United States Postal Serv	Office Building	25,554	Solar
Northeast Mangagement	Warehouse	25,688	Midler Ave N Rear
Franklin Lofts Llc	Det. Row Bldg.	25,700	Solar St & Plum
Cny, Regional Mrkt Auth	Warehouse	25,804	Hiawatha Blvd E
Upstate Llc	Manufacture	25,827	Erie Blvd E & Ives
Marjon Llc	Det. Row Bldg.	26,040	Clinton St S & Walton
Niagara Mohawk Power Corp	Office Building	26,400	Genesee St W
Central Ny Redevlpmnt Co	Det. Row Bldg.	26,416	Salina St S & Wood
Williams, John M	Manufacture	26,586	Ainsley
Maltbie/division Llc	Office Building	26,660	Maltbie
916-926 Wolf St Corp	Large Retail	26,724	Wolf St & Willumae Dr
Butternut Plaza Llc	Local Shop Ctr.	26,808	Butternut St & Mcbride
Burnet Ave Llc	1 use sm bldg	26,840	Burnet
Tal-Am Realty Llc	Att. Row Building	26,840	Salina St S To Bank
Canino, John A	Det. Row Bldg.	26,970	State St N & Laurel St E
Byrne Dairy Inc	Manufacture	27,464	Cortland Ave & Alexander
Page West Inc	Det. Row Bldg.	27,480	Geddes St S & Shonnard
Heritage Daniel Llc	Att. Row Building	27,495	Fayette St W To Walton
R-Force Llc	Manufacture	27,700	Washington St E & Walnut
Regal, Buick Properties	Auto Dealer	27,720	Hiawatha Blvd W
Schc Companies Inc	Det. Row Bldg.	27,729	Salina St S To Clinton
Gilels, Lionel	Office Building	27,752	Erie Blvd E
City Of Syracuse Td	Warehouse	27,892	Erie Blvd E & Beattie
Rellsey Properties Inc	>1 use sm. Bldg	27,920	Salina St N
Gonnella, August F	Warehouse	27,958	Erie Blvd W
Smith-Bentinck, Alan	Warehouse	28,072	Burnet Ave & Catherine
Barr, Brian G	Auto Dealer	28,500	Genesee St W & Leavenwort
Mjs Realty Holdings Llc	Auto Dealer	29,015	Genesee St W & Sand St

Table 27-2.Commercial Buildings in the City of Syracuse

Owner	Use	Square Footage	Street(s)
Becko Associates Llc	Multi-Use	29,063	Fayette St W
Canalwood Commons Llc	>1 use sm. Bldg	29,588	Erie Blvd E
719 East Genesee St Llc	Office Building	29,610	Genesee St E To Orange
3G Auto Corp	Auto Dealer	29,776	Genesee St W To Liberty
300-324 Hiawatha Bl E Llc	Warehouse	29,864	Hiawatha Blvd E & Carbon
Onondaga Commons Llc	>1 use sm. Bldg	29,944	Onondaga St W To Slocum A
Center Armory Assoc Llc	Det. Row Bldg.	30,000	Jefferson St W To Walton
185 Ainsley Dr Partnrshp	Manufacture	30,124	Ainsley
Ainsley Drive Realty Llc	Warehouse	30,131	Ainsley
Albany Ladder Co Inc	Warehouse	30,200	Hiawatha Blvd W
Jj&a Llc	Manufacture	30,283	Belden Ave W & Sand St &
Farmers & Traders Ins Co	Office Building	30,600	James St To Green
Salt City Properties Llc	Det. Row Bldg.	30,624	Clinton St S
Segal, Assoc Of Nj Lp	Warehouse	30,625	Spencer
Syracuse, Street Associate	Warehouse	30,625	Syracuse
Smith-Bentinck, Alan	Warehouse	30,720	Burnet Ave & Catherine
935 James St Llc	Office Building	30,750	James St To Highland
Giraffe Properties Llc	Large Retail	30,806	Park St & Hiawatha Blvd E
Greenwood Century Plaza LLC	Office Building	30,820	Warren St S & Jefferson S
Friends Of Jowonio Inc	Prof. Bldg	30,942	Genesee St E
DJ Curley Corp	Det. Row Bldg.	30,990	Warren St S
Sycamore Holdings Llc	Manufacture	31,014	Tully St & West St S To F
Sedlack Properties Llc	Manufacture	31,044	Geddes St N To Spencer
Ph Crane Llc	Auto Dealer	31,158	Genesee St W To Belden Av
Pioneer Midler Ave Llc	Manufacture	31,174	Midler Ave S & Midler Ram
Serling Jeanne K	Warehouse	31,196	Erie Blvd E & Townsend
Cabinet Fabrication Llc	Manufacture	31,207	Burnet Ave & Decker St &
Elmer, James I	Manufacture	31,461	State St N & Division
Mercy Works Inc	Warehouse	31,680	Salina St S
Tompkins Srm Llc	Warehouse	31,705	Oneida
Smith, John C Jr	Manufacture	31,860	Peat
United States Of America	Warehouse	32,021	Clinton St S & Washington
1401 Erie Blvd E Llc	Office Building	32,127	Erie Blvd E & Beech St N
Raulli Associates Llc	Manufacture	32,166	Teall Ave To Rr
Rasselas Associates Llc	Supermarket	32,214	Fayette St W To Erie
Bodow Realty	Manufacture	32,214	Park St & Hiawatha Blvd E
Visiting Nurse Assoc Of	Office Building	32,370	Genesee St W To Belden Av
Hiawatha Associates Llc	Auto Dealer	32,515	Hiawatha Blvd W
Sycamore Holdings Llc	Manufacture	32,530	Tully St & West St S To F
Fayette St Prop Llc	Warehouse	32,556	Niagara St & Fayette St W

Table 27-2.Commercial Buildings in the City of Syracuse

Owner	Use	Square Footage	Street(s)
Autocom Leasing Corp	Det. Row Bldg.	32,600	James St & North
South, Salina St Mall	Att. Row Building	32,640	Salina St S To Clinton
Otisca Industries Ltd	Warehouse	32,656	Mcbride St N & Butternut
Byrne Dairy Inc	Cold Storage	32,700	Oneida St & Adams St W
Wegmans Enterprises Inc	Supermarket	32,784	First North St & Pond
323-25 James St Llc	Det. Row Bldg	32,928	James St & State St N
Syr Indstrl Devl Agency	Parking Lot	33,000	Jefferson St W To Walton
Sjmj Llc	Auto Dealer	33,204	Genesee St W To Belden Av
Syr Indstrl Devl Agency	Office Building	33,330	Oswego
964 Spencer St Corp	Warehouse	33,400	Spencer
Syracuse University	Warehouse	33,408	Ainsley
Seville Enterprises Co	Office Building	33,443	James
Jse Associates Llc	Multi-Use	33,670	Tully St & Wyoming St
Alvord Aquisition Inc	Warehouse	33,760	Alvord St N
Triad Mmngmnt Group LLC	Manufacture	33,900	Clinton St N & Oswego Blv
1101 Investors Llc	Prof. Bldg	33,936	Erie Blvd E & University
Hillside Childrens Center	Manufacture	34,224	Wyoming St & Otisco St &
Brewster Medical Prop Llc	Prof. Bldg	34,416	Genesee St E & Walnut
West Genesee Prop LLC	Auto Dealer	34,802	Genesee St W & Dewey
100 New St Associates	Office Building	34,880	New
1401 Erie Blvd E Llc	Warehouse	35,150	Erie Blvd E & Beech St N
Solven Properties Corp	Office Building	35,200	James St & Mcbride St N
Migusa Llc	Att. Row Building	35,520	Walton
West Genesee Llc	Office Building	35,601	Genesee St W To Dewey
Allied Erie Llc	Warehouse	36,240	Erie Blvd W To Tracy
Tabunichikow & Vladislaw Inc	Multi-Use	36,302	Geddes St S To Fayette T
Strathmore Products Inc	Warehouse	36,420	Fayette St W & St Marks
S&R Associates Llc	Det. Row Bldg.	36,476	Fayette St W To Walton
Bdj Properties Llc	Warehouse	36,491	Leavenworth Ave To Maltbi
921-25 N State St Assoc Inc	Warehouse	36,543	State St N & Division
Talev, Kosta	Det. Row Bldg.	36,650	Fayette St W To Oswego
Hrr, Properties Company	Office Building	36,684	Montgomery St & Harrison
Church & Dwight Co Inc	Manufacture	37,000	Willis Ave To Emerson
Pg Erie Properties Llc	Prof Bldg	37,000	Water St E To Erie Blvd E
Gpl Associates Llc	Auto Dealer	37,170	Genesee St W & Leavenwort
Maltbie/division Llc	Office Building	37,524	Division St W
Reggie Real Estate Inc	Manufacture	37,676	Wolf St & Park
PPAR 3 Realty	Supermarket	37,756	Burnet
Gml Addis Llc	Att. Row Building	37,905	Salina St S
MDF Prop Hldngs LLC	Att. Row Building	38,280	Salina St S & Fayette

Table 27-2.Commercial Buildings in the City of Syracuse

Owner	Use	Square Footage	Street(s)
Taylor, Melanie	Det. Row Bldg.	38,352	Clinton St S To Walton
Syr Indstrl Devl Agency	Warehouse	38,744	Pulaski
Mertens Realty Corp	Manufacture	38,750	Pulaski
Schc Companies Inc	Prof. Bldg	38,900	Salina St S
Service Machine Corp Of	Manufacture	39,038	Burnet Ave & Elm St
Coolidge 518 Office Llc	Office Building	39,088	James St & Mcbride St N
Consolidated Industries	Manufacture	39,116	Seymour St To Shonnard
St Joseph's Health Center	Prof. Bldg	39,168	Townsend St N
Coolidge 344 Office Llc	Prof. Bldg	39,245	Genesee St W & Willow
Sci Corporation	Manufacture	39,678	Genant
Kjnk Llc	Manufacture	39,727	Jefferson St W & West
Sjmj Llc	Auto Dealer	39,900	Genesee St W & Geddes
Sjmj Llc	Auto Dealer	39,900	Genesee St W & Geddes
Erie Realty Holding Llc	Local Shop Ctr.	40,000	Erie Blvd E & Headson
Lahah, Darlene L	Warehouse	40,000	State St N
Willow St Lofts Llc	Det. Row Bldg.	40,044	Willow St W
Acn Companies Llc	Manufacture	40,148	Taylor St W & Oneida St
Triphammer, Properties Ltd	Warehouse	40,183	Lodi St & Wolf
Benbow Realty Llc	Manufacture	40,236	Hiawatha Blvd E & Sixth N
Panther Holding Co Llc	Warehouse	40,236	Lodi St & Court
432 N Franklin Prop Llc	Office Building	40,244	Franklin St N To Clinton
The Railroad Street	Att. Row Building	40,617	Salina St S & Washington
DJb Associates Llc	Det. Row Bldg.	40,632	Salina St N
Penfield Manufacturing Co	Manufacture	40,723	Salina St N & Exchange
459 Pulaski Street Inc	Manufacture	41,216	Pulaski
Tripp Enterprises Llc	Manufacture	41,250	Burnet
Tml Company Llc	Auto Dealer	41,288	Genesee St W
Pietrafesa Llc	Large Retail	41,472	Salina St N & Salt
Edco Sales Inc	Manufacture	41,500	Em Ave & Harbor
Clinton Square Suites LLC	Det. Row Bldg.	41,535	Genesee St W To Clinton Ser-son
Meat Town Market Inc	Det. Row Bldg.	41,664	Franklin St S & Jefferson
Rite Aid Of New York Inc	Att. Row Building	41,730	Salina St S & Fayette
438 N Franklin Llc	Warehouse	42,352	Franklin St N & Genant
Bova, Susan	Warehouse	42,416	Genesee St E & Cherry
South Clinton Realty	Manufacture	42,510	Clinton St S & Tallman
Thermopatch Corporation	Manufacture	42,732	Erie Blvd E & Beattie
James, St Lp	Office Building	42,886	James St To Willow St E
220 South Warren Llc	Office Building	43,560	Warren St S & Fayette
Bbd Coaters Inc	Warehouse	43,710	Otisco St & West St to Tully

Table 27-2.Commercial Buildings in the City of Syracuse

Owner	Use	Square Footage	Street(s)
Edward Joy Electric Llc	Manufacture	43,736	Canal
Syracuse, University	Local Shop Ctr.	44,160	University Ave To Adams S
Syr Indstrl Devl Agency	Parking Lot	44,690	Genesee St E & Warren
Bdj Properties Llc	Warehouse	44,875	Leavenworth Ave
One Clinton Sq Assoc Llc	Bank Complex	45,493	Salina St N & James St
Sycamore Holding Llc	Manufacture	47,116	Oneida St & Larned St
Penfield Manufacturing Co	Manufacture	47,816	Salina St N & Exchange
Route 20/20 Llc	Office Building	47,952	Genesee St E To Mccarthy
New York State	Office Building	48,000	Stadium
Baruch Zvi Holdings Llc	Manufacture	48,384	Maple St & Washington
Syracuse Scale Co Inc	Manufacture	48,400	Solar St & Division St W
Hogan Blk Realestate LLC	Att. Row Building	48,800	Fayette St W & Franklin S
City Of Syracuse	Multi-Use	48,879	Genesee St E & Warren
Badoud Properties Llc	Bank Complex	49.182	Genesee St W To Belden Av
Nik Realty Llc	Local Shop Ctr.	49,443	Geddes St S & Marcellus S
Gross Square Footage 50,000 - 100,000 S.F.			
Madison Environmental	Office Building	50,080	James
Muench Kreuzer Candle Co	Warehouse	50,540	Hiawatha Blvd E & Second
Business, Venture Assoc	Prof. Bldg.	50,801	Genesee St E & Crouse
Northeast Management	Warehouse	50,900	Midler Ave N Rear
Sweeney, Walter	Warehouse	52,220	Water St W To Erie Blvd W
450 S Salina St Prtnrship	Office Building	52,664	Salina St S To Clinton
City Of Syracuse-Bova	Warehouse	52,750	Erie Blvd W & Magnolia
City Of Syracuse Td	Office Building	52,752	Salina St S
Uas Llc	Warehouse	52,757	Tracy
Inland Supply Inc	Warehouse	53,040	Wilkinson St & Plum
Rago Syracuse Inc	Manufacture	53,324	Wilkinson St & Barker
Pemco Montgomery St Llc	Office Building	53,748	Montgomery St & Fayette S
636 S Warren St Llc	Office Building	53,788	Warren St S & Adams St E
Muench Kreuzer Candle Co	Manufacture	53,951	Hiawatha Blvd E & Second
Rimualdo Scott	Manufacture	54,802	Fayette St W & Seneca
499 Syr City Centre Llc	Manufacture	55,452	Erie Blvd W & Leavenworth
Netti Wholesale Grcery	Warehouse	55,750	Fourth North St Rear
The Railroad Street	Office Building	56,188	Salina St S To Bank
Empire Archives Inc	Warehouse	58,000	Hiawatha Blvd E
The Herald Publish Co Llc	Manufacture	58,112	Salina St N To Clinton
Catholic, Charities	Office Building	58,281	Onondaga St W To Rowland
499 Syr City Centre Llc	Bank Complex	58,776	Warren St S To Onondaga S
The, Salvation Army	Office Building	58,862	Salina St S
Krell, John F	Office Building	59,520	Herald Pl & Franklin St N

Table 27-2.Commercial Buildings in the City of Syracuse

Owner	Use	Square Footage	Street(s)
455 North Franklin Llc	Office Building	59,796	Franklin St N & Plum
Vibrant, Syracuse Spaces	Multi-Use	59,822	Geddes St S & Fayette
GA Braun Inc	Manufacture	60,547	Brighton Ave E
Hiawatha Realty Corp	Manufacture	60,900	Hiawatha Blvd W To Pulask
The Herald Publish Co Llc	Manufacture	61,458	Salina St N To Clinton
Bobbett Family Llc	Warehouse	62,116	Geddes St N
Key Bank of Central NY	Bank	62,616	Washington St E & Warren
City Of Syracuse-Bova	Warehouse	62,665	Erie Blvd W & Magnolia
Byrne Dairy Inc	Cold Storage	62,950	Oneida St & Adams St W
Syr Indstrl Devl Agency	Reg'l Shop Ctr.	64,080	Carousel Center
Boukair Realty Llc	Auto Dealer	64,121	Hiawatha Blvd W
Arec Ii Llc	Warehouse	64,614	Erie Blvd E To Water St E
Penfield Manufacturing Co	Manufacture	65,056	Salina St N & Exchange
Bill Rapp Pontiac Inc	Auto Dealer	65,084	Burnet
Storico Development Llc	Office Building	65,472	Salina St S & Jefferson S
Northeast Management	Warehouse	65,800	Midler Ave N Rear
600 E Genesee St Llc	Prof. Bldg.	66,672	Genesee St E
Syr Indstrl Devl Agency	Office Building	66,732	Plum
Syr Indstrl Devl Agency	Supermarket	67,130	Erie Blvd E
Jefferson Cntr Assoc Inc	Att. Row Bldg.	67,212	Salina St S To Bank St &
600 Erie Place Prtnrshp	Office Building	67,393	Erie Blvd W
Franklin Lofts Llc	Att. Row Bldg.	67,750	Plum St To Solar
Emo, Properties	Office Building	67,970	Water St W & Franklin
United Partners Mgmt Llc	Office Building	68,185	Warren St S
Expressway Properties Llc	Office Building	68,707	Division St W & Clinton S
Killian Mfg Corp	Manufacture	70,900	Burnet
450 S Salina Llc	Office Building	72,414	Salina St S To Clinton
Axis Group Inc	Warehouse	72,906	Clinton St N & Spencer
Syracuse University	Warehouse	73,824	Ainsley
Swanson Fulton St Llc	Warehouse	76,204	Genant Dr To Clinton St N
Continental, Warehousing	Warehouse	76,736	Water St E & University
Armory Parking Assoc Llc	Parking Garage	77,112	Clinton St S
Paragon Supply Inc	Warehouse	77,336	Syracuse
Gsi Of Virginia Inc	Manufacture	79,600	Greenway
Wl Llc	Office Building	80,388	Salina St S & Fayette
Syracuse University	Warehouse	81,324	Ainsley
Niagara Mohawk Power Corp	Office Building	81,432	Erie Blvd W & Franklin
Empire Archives Inc	Det. Row Bldg.	84,540	Salina St S
Teall Properties Llc	Manufacture	84,734	Teall Ave & Lynch
Syr Indstrl Devl Agency	Bank Complex	85,215	Salina St S & Water St E

Table 27-2.Commercial Buildings in the City of Syracuse

Owner	Use	Square Footage	Street(s)
Syracuse Bangkok Llc	Multi-Use	85,968	Montgomery St & Jefferson
Clinton St Soma	Warehouse	86,176	Clinton St N & Division S
2468 Group Inc	Local Shop Ctr.	87,950	Salina St S & Fillmore Av
Cny Regional Market	Warehouse	88,600	Park
Cny, Regional Market	Cold Storage	88,600	Tex Simone
Benbow Realty Llc	Manufacture	88,874	Hiawatha Blvd E & Sixth N
Skinner Development Corp	Local Shop Ctr	89,082	James St & Walter Dr & La
Cim Physicians Bldg Llc	Prof. Bldg.	90,000	Irving
Middleneck Road Llc	Manufacture	92,113	Fayette St W
Harrison Cntr Assoc	Prof. Bldg.	94,703	Adams St E To Harrison
Syracuse University	Parking Garage	96,000	Irving Ave & Raynor
Gross Square Footage 100,000 - 200,000 S.F.			
Franklin Lofts Llc	Det Row Bldg.	102,800	Solar St & Plum
220 South Warren Llc	Office Bldg.	104,640	Warren St S & Fayette
Vinum Parking Garage Llc	Parking Garage	108,800	Evans
Syracuse Mob Llc	Prof. Bldg.	111,000	Irving
Syr, Property Holdings In	Office Bldg.	111,020	Warren St S & Fayette
90 Presidential Plaza	Office Bldg.	112,016	Harrison St & Townsend
Lampuri, Concetto	Warehouse	113,515	Marcellus St & Fayette
Jaquith Industries Inc	Manufacture	113,888	Brighton Ave E
Rockwest Ctr Rlty Corp	Warehouse	115,030	Marcellus St To Fayette
Richmond Ave Devel Llc	Manufacture	116,595	Richmond Ave
Syracuse University	Parking Garage	117,900	Marshall St Rear
Syr Indstrl Devl Agency	Reg'l Shop Ctr.	118,008	Carousel Center
Coyne International Corp	Manufacture	118,502	Cortland Ave & Tallman
Syr Indstrl Devl Agency	Reg'l Shop Ctr.	124,320	Carousel Center
224 Harrison Associates	Office Bldg.	126,156	Harrison St & Harrison
Richmond Ave Devel Llc	Warehouse	126,338	Richmond Ave To Tracy
400 Erie Blvd Llc	Warehouse	129,382	Erie Blvd W & Plum St
Hiawatha Blvd E LLC	Warehouse	129,916	Hiawatha Blvd E
Rockwest Ctr Relty Corp	Warehouse	129,916	Marcellus St & Seneca
Asgrec Two Inc	Bank Complex	129,916	Warren St S & Jefferson S
Syr Indstrl Devl Agency	Office Bldg.	134,385	Plum St & Onondaga
Vinlandic Llc	Office Bldg.	134,880	Warren St S & Washington
City Of Syracuse	Parking Garage	135,142	Warren St S & Jefferson S
Sam's Real Estate Trust	Large Retail	136,114	Erie Blvd E
Pioneer Midler Ave Llc	Large Retail	137,569	Simon Dr Rear
Congel, Suzanne D/b/a	Office Bldg.	144,765	Clinton St N & Genesee
United States Of America	Parking Garage	146,208	Irving Ave & Vanburen
Wegmans Enterprises Inc	Local Shop Ctr.	147,250	Onondaga Blvd Rear

Table 27-2.Commercial Buildings in the City of Syracuse

Owner	Use	Square Footage	Street(s)
Syracuse Mob Llc	Parking Garage	150,400	Crouse Ave S & Waverly Av
City Of Syracuse	Parking Garage	151,740	Fayette St E & Montgomery
600 Erie Place Prtnrshp	Office Bldg.	152,406	Erie Blvd W To Tracy St &
City Of Syracuse	Parking Garage	157,728	Irving
Syr Indstrl Devl Agency	Parking Garage	158,816	Crouse Ave S
Syracuse Portfolio Llc	Office Bldg.	159,936	Salina St S & Onondaga
Dupli Associates Llc	Manufacture	160,472	Franklin St N To Solar
Syr Indstrl Devl Agency	Parking Garage	160,550	Salina St S & Washington
St Josephs Health Center	Parking Garage	162,440	Townsend St N & Laurel
Syr Indstrl Devl Agency	Office Bldg.	162,709	Salina St S & Washington
City Of Syracuse	Parking Garage	165,030	Washington St W
Esls Development Llc	Parking Garage	165,030	Warren St S
Syr Indstrl Devl Agency	Reg'l Shop Ctr.	178,904	Carousel Center
City Of Syracuse	Parking Garage	183,456	Salina St S & Jefferson S
Syr Indstrl Devl Agency	Reg'l Shop Ctr.	185,495	Carousel Center
Syr Indstrl Devl Agency	Office Bldg.	185,530	Clinton St S & Fayette
800 Nottingham Rd Corp	Manufacture	187,000	Tyson Pl To Coughlin
Blue Cross & Blue Shield	Office Bldg.	190,498	Warren St S To Bank
Delavan Center Inc	Warehouse	191,480	Fayette St W & Niagara
Syracuse Business Center Inc	Manufacture	192,256	Wilkinson St
Syr Indstrl Devl Agency	Reg'l Shop Ctr.	194,788	Carousel Center
Gml Parking Llc	Reg'l Shop Ctr.	196,416	Salina St S & Harrison
West Side Initiative Inc	Warehouse	197,308	Wyoming St & Fayette St
Gross Square Footage 200,000 - 500,000 S.F.			
Business, Venture Assoc	Professional Bldg.	208,488	Genesee St E & Crouse
State, Tower Of Syracuse	Office Building	215,578	Genesee St E & Warren
Crouse Health System Inc	Parking Garage	218,400	Irving Ave & Adams St E
City Of Syracuse	Office Building	237,303	Harrison St & Warren St S
Deys, Centennial Plaza Inc	Office Building	241,638	Salina St S & Jefferson S
1 Park Place Llc	Office Building	252,910	State St S & Fayette St E
New York State	Prof. Bldg.	256,425	Irving
Syracuse University	Parking Garage	257,000	Adams St E & University
Syr Indstrl Devl Agency	Parking Garage	259,216	Fayette St W & Franklin S
Northern Yankees RE Llc	Manufacture	261,800	Spencer St To Solar St
United States Of America	Office Building	275,732	Clinton St S & Washington
Syr Indstrl Devl Agency	Office/Retail	288,170	Salina St S To Warren
Niagara Mohawk Power Corp	Office Building	296,022	Erie Blvd W & Franklin
900 Washington St Llc	Office Building	297,376	Washington St E & State S
Syr Indstrl Devl Agency	Office Building	299,754	Salina St S & Jefferson S

Table 27-2.Commercial Buildings in the City of Syracuse

Owner	Use	Square Footage	Street(s)
Ny Job Dev Authority	Warehouse/Mixed Use	301,424	Brighton Ave E & Ainsley
City Of Syracuse &	Parking Garage	338,682	State St S & Adams St E
Hub Properties Trust	Office Building	367,508	Fayette St W & Clinton
Rockwest Developers Inc	Mixed Use	389,820	Marcellus St to W Fayette
City Of Syracuse	Parking Garage	408,139	Warren St S & Adams St E
Gross Square Footage > 500,000 S.F.			
Syr Indstrl Devl Agency	Reg'l Shop Ctr.	847,042	Carousel Center
MONY/AXA Towers	Office Bldg	1,060,498	Madison St & Warren St S

28.0 Appendix 3 - Miscellaneous Issues: Skaneateles Lake Option

28.1 Potential Future Treatment for Skaneateles Lake Supply

The City of Syracuse currently has a filtration avoidance determination for their Skaneateles Lake supply under the United States Environmental Protection Agency (USEPA) Surface Water Treatment Rules (SWTRs). With filtration avoidance, the City is only required to maintain chlorination to achieve 3-log giardia activation, which is achieved through contact time available from the point of application of chlorine in Skaneateles to its entry to the city. The city has been dedicated to maintaining filtration avoidance to avoid the cost of construction of a +60 mgd water filtration plant for their supply.

If the city were to lose filtration avoidance, under the SWTRs, they would be required to construct a filter plant. Previous studies have indicated that the most desirable location for a filter plant would be along the city conduits between Skaneateles and the city. The addition of a water treatment plant along the conduits would have no direct impact on the function of the cooling system with the exception that it would introduce additional headlosses along the conduit system and reduce carrying capacity to the city, potentially requiring pumping under certain demand conditions. The design of a water treatment plant would need to consider the additional headloss associated with its operation, as well as the losses through the heat exchange facility in the pumping system design. In addition, there may be a small thermal loss associated with the plant, depending on the process selected for water filtration, potentially reducing the efficiency of the heat exchangers in the future.

The Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), promulgated in 2006, will require that the City of Syracuse provide additional treatment for cryptosporidium. These facilities will need to be operational by 2012. Ultraviolet light (UV) disinfection is the likely treatment technology for this additional treatment requirement. We understand the city is anticipating construction of UV disinfection facilities at their existing reservoir sites (Westcott and Woodland). The addition of UV disinfection will not have a direct impact on the feasibility of the chilled water system; however, similar to a filtration plant, will introduce some minor headloss through the UV disinfection facility (likely less than 5 feet (1.5 m)). These possible future headlosses should be considered in the design of the pumping and heat exchange facilities in order to maintain appropriate capacities along the conduit system to the city.

28.1.1 Impact of Open Reservoirs

28.1.1.a City of Syracuse Skaneateles Lake Supply

The City of Syracuse currently uses two open finished water reservoirs (Woodland and Westcott) for distribution storage. The 2006 LT2ESWTR will require that the city cover, treat, or replace their open finished water reservoirs by the year 2012. For compliance with this Rule, the city is currently constructing two 33 million gallon water storage tanks inside Westcott Reservoir and will eventually have to add treatment or storage tanks or covers to Woodland Reservoir. Based on the proposed location of a heat exchange facility near the Andrews Gatehouse, we do not believe the need for LT2ESWTR compliance facilities at the Woodland and Westcott Reservoirs will have an impact on the feasibility of the chilled water system.

28.1.1.b Metropolitan Water Board Open Reservoirs

The MWB currently uses three open finished water reservoirs (Terminal, Eastern and Western) for storage of finished water for the distribution system. Similar to Syracuse, the MWB will be required to construct compliance facilities for LT2ESWTR. The MWB currently has plans in place to construct water storage tanks in Eastern Reservoir and a water storage tank in Western Reservoir, and has recently initiated a study for compliance facilities for Terminal Reservoir. Because the proposed discharge location for thermally harvested water will be back to the water distribution system and the reservoirs would be downstream of the heat exchange facilities, we do not believe the MWB plans for these reservoirs will have an impact on the Naturally Chilled Water (NCW) feasibility, with the exception that there will be reduced volume of storage available within the MWB system after construction of the storage tanks. This may increase the frequency that the outfall will be exercised during periods when cooling demands exceed potable water demands.

28.2 Technical Items Considered

A number of technical items which would affect the efficiency of a Naturally Chilled Water system were identified during the development of this report. This section contains a summary of the various items. More complete information on several of the items is contained in Task 14, Miscellaneous Issues.

28.2.1 Thermal Loss

Cold lake water will gain a certain amount of heat while travelling through a buried pipeline. While it is possible that the water traveling in the pipeline could lose heat during cold winter months, that case is not studied since marginally colder water delivered during winter months would not cause a significant economic impact. The warming of the cold water during summer months is of more concern since it could limit the amount of cooling delivered during the critical period when more cooling is needed. The amount of heat gained during transmission from the lake intake to the point of customer use will be impacted by outdoor air temperature, depth of bury, pipe thickness and material, and the types of soils surrounding the buried pipe. A summary of expected summertime warming within the pipeline is presented here, and a more detailed analysis including technical information is included in Chapter 10.

28.2.1.a Lake Ontario Route

The proposed route from Lake Ontario to downtown Syracuse is approximately 32 miles. At a flow velocity of 7 feet per second, the residence time of chilled water in the pipeline is approximately 6.7 hours. During the summer months when average air temperatures reach over 70°F, the expected temperature rise for water traveling through the pipeline is approximately 1.5°F, or about 0.04ºF per mile of pipeline.

28.2.1.b Skaneateles Lake Route

The proposed route from Skaneateles Lake to downtown Syracuse is approximately 15 miles. At a flow velocity of 7 feet per second, the residence time of chilled water in the pipeline is approximately 3.1 hours. During the summer months when average air temperatures reach over 70°F, the expected temperature rise for water traveling through the pipeline is approximately 3.2°F, or about 0.21ºF per mile of pipeline. The reason for the 3.2°F increase over the 15-mile route is that the cool lake water would travel through the three existing conduits, resulting in a large pipe surface area exposed to warmer soils.

In either case, the amount of thermal warming in summer is not significant. The intake temperatures are approximately 39°F at either lake intake source; therefore, the delivered water temperature is still approximately 41º to 43°F at the heat exchange facility. Insulating the buried piping runs could reduce the amount of thermal warming experienced, but does not appear to be justified since the warming expected is minor.

Actual operating data from the Toronto and Cornell Lake Source Cooling projects show a temperature gain of approximately 0.12ºF degrees per mile of pipeline, which is similar to our predicted warming of 0.04 to 0.21ºF per mile of pipeline based on empirical methods.

28.2.2 Hot Water Heating

A portion of the potable water delivered to residences and businesses is heated for various uses. If a naturally chilled water system were installed, the average delivery temperature of potable water to customers could change. If the average potable water delivery temperature was to decrease as a result of a naturally chilled water project, a certain amount of energy would be required in the hot water heating systems of water users. Alternately, if the average delivery temperature increased, the amount of energy used to heat the water would decrease. The factors affecting the delivery temperature include the temperature of water at intake, the temperature rise through any heat exchange facility, ground temperature, and the residence time in the potable deliver system.

The intake water temperature for each of the options is approximately 39°F. During summer conditions, the temperature will rise by 1.5 to 3.0°F after traveling through a pipeline to the heat exchange facility. The expected temperature rise through the heat exchanger is approximately 10°F, after which the water would be added back to reservoirs or water towers within the existing potable water system at a temperature of 51 to 54°F. Historical data shows that the potable water stored in the reservoirs during the warmest part of the summer is at approximately 70º to 72°F, with two to three days' volume of water stored. The effect of warm air temperatures warming the reservoirs and warm ground temperatures warming the buried distribution piping system would minimize any temperature difference at residential or commercial connections to the potable water system.

During the winter months, there will be no significant difference between the existing delivered water temperatures and the expected delivery temperatures from a naturally chilled water project, since the intake temperature for each scenario would be the same, and cold ground conditions would equalize any temperature difference between the two systems.

One other condition worthy of consideration is when the heat exchange facility is not in use. In this scenario, the cool water would be sent directly to the reservoirs at a temperature of 41° to 44°F, much cooler than traditional water temperatures. After several days' storage and delivery through the underground piping system, the water could arrive at customer connections several degrees cooler than normal. Assuming that the water arrives 10°F cooler than the traditional average (during the warmest month), the estimated cost to heat the water the extra 10°F during the warmest summer month would be $1,200 per day, which would be divided among all users. This cost would decrease in cooler weather and would be negligible in the six colder months. The $1,200 per day heating cost was based on the following assumptions:

- Total flow of 47 mgd.
- 25 percent of total flow is used for hot water.
- Natural gas water heater at 80 percent efficiency.
- Natural gas cost of $10 per million BTU delivered.
- Heating requires 1.0 BTU per pound per °F of temperature rise.
- Water weighs 8.34 pounds per gallon.

29.0 Appendix 4 - Invasive Species

29.1 Section Introduction

The table on the following pages identifies known exotic species purposefully or inadvertently introduced into the Lake Ontario basin. Clearly, the system has been affected by these introductions, and is considerably different because of the them.

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Algae	Hemidis-caceae	*Actinocyclus normanii fo. subsalsa*	diatom	Exotic	Europe	1938	established	No
Algae	Bangiaceae	*Bangia atro-purpurea*	red alga	Native	North America	1979	established	No
Algae	Porphyridi-aceae	*Chroodacty-lon ramosum*	red alga	Cryptogenic	North America	1982	established	No
Algae	Stephanodis-caceae	*Cyclotella ato-mus*	diatom	Cryptogenic	Unknown	1987	established	No
Algae	Stephanodis-caceae	*Cyclotella cryptica*	diatom	Cryptogenic	Unknown	1993	established	No
Algae	Stephanodis-caceae	*Cyclotella pseudostellig-era*	diatom	Cryptogenic	Unknown	1993	established	No
Algae	Ulvaceae	*Enteromor-pha intestina-lis*	green alga, grass kelp	Native	North America	1926	established	No
Algae	Skeletone-mataceae	*Skeletonema potamos*	diatom	Cryptogenic	Unknown	1993	established	No
Algae	Skeletone-maceae	*Skeletonema subsalsum*	diatom	Exotic	Eurasia	1993	established	No
Algae	Stephanodis-caceae	*Stephanodis-cus bindera-nus*	diatom	Exotic	Eurasia	1945	established	No
Algae	Stephanodis-caceae	*Stephanodis-cus subtilis*	diatom	Exotic	Eurasia	1972	established	No
Algae	Thalassiosir-aceae	*Thalassiosira baltica*	diatom	Exotic	Eurasia	1988	established	No

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin (Continued)

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Algae	Thalassiosiraceae	*Thalassiosira pseudonana*	diatom	Cryptogenic	Unknown	1993	established	No
Algae	Thalassiosiraceae	*Thalassiosira weissflogii*	diatom	Cryptogenic	Unknown	1993	established	No
Annelids-Oligochaetes	Tubificidae	*Potamothrix bedoti*	tubificid worm	Exotic	Eurasia	1950	established	Yes
Annelids-Oligochaetes	Tubificidae	*Potamothrix moldaviensis*	tubificid worm	Exotic	Eurasia	1952	established	Yes
Annelids-Oligochaetes	Tubificidae	*Potamothrix vejdovskyi*	tubificid worm	Exotic	Eurasia	1971	established	Yes
Arthropoda	Crambidae	*Acentropus niveus*	European aquatic/ water moth	Exotic	Europe	1927	established	Yes
Arthropoda	Erirhinidae	*Tanysphyrus lemnae*	duckeed/ aquatic weevil	Exotic	Europe	1934	established	Yes
Bacteria	Pseudomona daceae	*Aeromonas salmonicida*	furunculosis, ulcer disease, erythrodermatitis	Exotic	Unknown	2006	establishe	No
Bacteria	Corynebacteriaceae	*Renibacterium salmoninarum*	bacterial kidney disease (BKD), Dee disease	Exotic	Europe	2005	established	No
Coelenterates-Hydrozoans	Clavidae	*Cordylophora caspia*	freshwater hydroid	Exotic	Eurasia	2007	established	?
Coelenterates-Hydrozoans	Olindiidae	*Craspedacusta sowerbyi*	freshwater jellyfish	Exotic	Asia	1999	collected	No
Crustaeans-Amphipods	Gammaridae	*Echinogammarus ischnus*	amphipod	Exotic	Europe	2000	collected, established	Yes

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin (Continued)

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Crustaceans - Amphiods	Gammaridae	*Gammarus tigrinus*	amphipod	Native	North America	2004	established	Yes
Crustaceans - Cladocerans	Cer-copagidae	*Bythotrephes longimanus*	spiny water flea	Exotic	Europe	1982	established	Yes
Crustaceans - Cladocerans	Cer-copagidae	*Cercopagis pengoi*	fishhook waterflea	Exotic	Asia	1998	established	Yes
Crustaceans - Cladocerans	Bosmin-idae	*Eubosmina coregoni*	water flea	Exotic	Europe	1967	established	Yes
Crustaeans-Copepods	Temoridae	*Eurytemora affinis*	calanoid copepod	Native?	North America	1958	established	Yes
Crustaeans-Copepods	Ameiridae	*Nitokra hiber-nica*	harpacticoid copepod	Exotic	Eurasia	1973	established	No
Crustaeans-Copepods	Diaptomidae	*Skistodiapto-mus pallidus*	calanoid copepod	Native	North America	1967	established	Yes
Crustaeans-Mysids	Mysidae	*Hemimysis anomala*	bloody red shrimp	Exotic	Eurasia	2006	collected, established	Yes
Fishes	Clupeidae	*Alosa aestiva-lis*	blueback herring	Native	North America	1981	established	Yes
Fishes	Clupeidae	*Alosa pseudo-harengus*	alewife	Native	North America	1868	established	Yes
Fishes	Gobiidae	*Apollonia (Neogobius) melanostomus*	round goby	Exotic	Eurasia	1998	established	Yes
Fishes	Cyprinidae	*Carassius auratus*	goldfish	Exotic	Asia	1978	collected, established	No
Fishes	Cyprinidae	*Cyprinus car-pio*	common carp	Exotic	Eurasia	1980	established	No
Fishes	Centrarch-idae	*Enneacanhus gloriosus*	bluespotted sunfish	Native	North America	1971	established	No
Fishes	Moronidae	*Morone amer-icana*	white perch	Native	North America	1925	collected, established	No

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin (Continued)

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Fishes	Ictaluridae	*Noturus insignis*	margined madtom	Native	North America	1928	established, extirpated?	No
Fishes	Salmonidae	*Oncorhynchus gorbuscha*	pink salmon	Native	North America	1979	established	No
Fishes	Salmonidae	*Oncorhynchus kisutch*	coho salmon	Native	North America	1968	established	Yes
Fishes	Salmonidae	*Oncorhynchus mykiss*	rainbow trout	Native	North America	1885	failed, stocked	No
Fishes	Salmonidae	*Oncorhynchus nerka*	kokanee, sockeye	Native	North America	1980	established, stocked	Yes
Fishes	Salmonidae	*Oncorhynchus tshawytscha*	Chinook salmon	Native	North America	1954	established, stocked	Yes
Fishes	Osmeridae	*Osmerus mordax*	rainbow smelt	Native	North America	1929	established	Yes
Fishes	Salmonidae	*Salmo trutta*	brown trout	Exotic	Europe	1833	collected, established	No
Fishes	Cyprinidae	*Scardinius erythrophthalmus*	rudd	Exotic	Eurasia	1931	collected, established	No
Mollusks-Bivalves	Corbiculidae	*Corbicula fluminea*	Asian clam	Exotic	Asia	1999	established	No
Mollusks-Bivalves	Dreissenidae	*Dreissena polymorpha*	zebra mussel	Exotic	Eurasia	1989	established, unknown	Yes
Mollusks-Bivalves	Dreissenidae	*Dreissena rostriformis bugensis*	quagga mussel	Exotic	Eurasia	1990	established	Yes

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin (Continued)

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Mollusks-Bivalves	Unionidae	*Lasmigona subviridis*	green floater	Native	North America	1959	unknown	No
Mollusks-Bivalves	Sphaeriidae	*Pisidium amnicum*	greater European pea/ pill clam, pisidiid clam	Exotic	Eurasia	1897	established	No
Mollusks-Bivalves	Sphaeriidae	*Pisidium henslowanum*	Henslow peaclam	Exotic	Eurasia	2001	established	No
Mollusks-Bivalves	Sphaeriidae	*Pisidium supinum*	hump-backed peaclam	Exotic e	Eurasia	1959	stablished	No
Mollusks-Bivalves	Pisidiidae	*Sphaerium corneum*	European fingernail clam	Exotic	Eurasia	1900	established	No
Mollusks-Gastropods	Bithyniidae	*Bithynia tentaculata*	mud bithynia, Faucet snail	Exotic	Europe	1879	established	No
Mollusks-Gastropods	Viviparidae	*Cipangopaludina chinensis malleata*	Chinese mystery snail	Exotic	Asia	1978	established	No
Mollusks-Gastropods	Pleuroceridae	*Elimia virginica*	Piedmont elimia	Native	North America	1967	collected, established	No
Mollusks-Gastropods	Hydrobiidae	*Gillia altilis*	buffalo pebble snail	Native	North America	1915	established, extirpated	No
Mollusks-Gastropods	Hydrobiidae	*Potamopyrgus antipodarum*	New Zealand mud snail	Exotic	Asia	1991	collected, established	?
Mollusks-Gastropods	Lymnaeidae	*Radix auricularia*	big-ear radix	Exotic	Europe	1930	collected, established	?

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin (Continued)

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Mollusks-Gastropods	Valvatidae	*Valvata piscinalis*	European stream valvata	Exotic	Europe	1897	collected, established	No
Mollusks-Gastropods	Viviparidae	*Viviparus georgianus*	banded mystery snail	Native	North America	1993	established	No
Plants	Poaceae	*Agrostis gigantea*	Redtop, black bent, water bentgrass	Exotic	Eurasia	1929	collected	No
Plants	Betulaceae	*Alnus glutinosa*	Black alder	Exotic	Eurasia	1964	collected	No
Plantss	Poaceae	*Alopecurus geniculatu*	water foxtail, marsh meadow-foxtail	Exotic	Eurasia	2008	collected	No
Plants	Butomaceae	*Butomus umbellatus*	flowering rush	Exotic	Europe	1929	collected, established	No
Plants	Cabombaceae	*Cabomba caroliniana*	Carolina fanwort	Native	North America	2008	collected	No
Plants	Cyperaceae	*Carex disticha*	Sedge	Exotic	Eurasia	1866	established	No
Plants	Chenopodiaceae	*Chenopodium glaucum*	Oak-leaved goosefoot	Exotic	Eurasia	1867	collected, established	No
Plants	Asteraceae	*Cirsium palustre*	Marsh Thistle	Exotic	Eurasia	2008	collected	No
Plants	Apiaceae	*Conium maculatum*	Poison hemlock	Exotic	Eurasia	2008	collected	No
Plants	Poaceae	*Echinochloa crusgalli*	Barnyard grass	Exotic	Eurasia	1919	collected	No
Plants	Onagraceae	*Epilobium hirsutum*	Great hairy willow herb	Exotic	Eurasia	1874	collected, established	No

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin (Continued)

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Plants	Rhamnaceae	*Frangula alnus*	Glossy buck-thorn	Exotic	Eurasia	1913	established	No
Plants	Poaceae	*Glyceria max-ima*	reed manna grass	Exotic	Eurasia	1940	established	No
Plants	Hydrochari-taceae	*Hydrocharis morsus-ranae*	common frogbit	Exotic	Europe	1974	established	No
Plants	Balsami-naceae	*Impatiens glandulifera*	Indian bal-sam	Exotic	Asia	2008	collected	No
Plants	Iridaceae	*Iris pseuda-corus*	yellow iris	Exotic	Europe and Africa	1886	collected, established	No
Plants	Juncaceae	*Juncus com-pressus*	Flattened rush	Exotic	Eurasia	1895	established	No
Plants	Juncaceae	*Juncus gerar-dii*	Black-grass rush	Native	North America	2008	collected	No
Plants	Juncaceae	*Juncus inflexus*	Rush, Euro-pean meadow rush	Exotic	Eurasia	1922	collected, established	No
Plants	Lamiaceae	*Lycopus asper*	Western water hore-hound	Native	North America	2008	collected	No
Plants	Lamiaceae	*Lycopus euro-paeus*	European water hore-hound	Exotic	Eurasia	1903	collected, established	No
Plants	Primulaceae	*Lysimachia nummularia*	Moneywort	Exotic	Eurasia	1882	collected, established	No
Plants	Primulaceae	*Lysimachia vulgaris*	yellow loosestrife	Exotic	Asia	1913	collected, established	No
Plants	Lythraceae	*Lythrum sali-caria*	purple loosestrife	Exotic	Eurasia	1869	collected, established	No

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin (Continued)

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Plants	Marsileaceae	*Marsilea quadrifolia*	European water-clover	Exotic	Eurasia	1893	collected, established	No
Plants	Lamiaceae	*Mentha aquatica*	watermint	Exotic	Eurasia	2008	collected	No
Plants	Lamiaceae	*Mentha gracilis*	Creeping whorled mint, ginger-mint	Exotic	Eurasia	1915	collected, established	No
Plants	Lamiaceae	*Mentha spicata*	Spearmint	Exotic	Eurasia	2008	collected	No
Plants	Boraginaceae	*Myosotis scor-pioides*	True forget-me-not	Exotic	Eurasia	1886	collected, established	No
Plants	Halor-agaceae	*Myriophyl-lum spicatum*	Eurasian water-milfoil	Exotic	Eurasia	1974	collected, established	Possibly
Plants	Najadaceae	*Najas marina*	Spiny naiad	Native	Unknown	1864	collected, established	No
Plants	Najadaceae	*Najas minor*	brittle naiad	Exotic	Eurasia	1935	collected, established	No
Plants	Brassicaceae	*Nasturtium officinale*	water cress	Exotic	Eurasia	1847	collected, established	No
Plants	Asteraceae	*Pluchea odor-ata*	sweetscent	Native	North Amer-ica	1950	established	No
Plants	Poaceae	*Poa trivalis*	rough blue-grass	Exotic	Eurasia	1929	collected	No
Plants	Polygo-naceae	*Polygonum persicaria*	Lady's thumb, smartweed, spotted knot-weed	Exotic	Eurasia	2008	collected	No

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin (Continued)

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Plants	Potamogetonaceae	*Potamogeton crispus*	curly pondweed	Exotic	Europe	1879	collected, established	No
Plants	Poaceae	*Puccinellia distans*	Weeping alkali grass	Exotic	Eurasia	1893	collected, established	No
Plants	Brassicaceae	*Rorippa sylvestris*	Creeping yellow cress	Exotic	Eurasia	1884	collected, established	No
Plants	Polygonaceae	*Rumex longifolius*	Yard dock	Exotic	Eurasia	2008	collected	No
Plants	Polygonaceae	*Rumex obtusifolius*	Bitter dock	Exotic	Eurasia	2008	collected	No
Plants	Salicaceae	*Salix alba*	White willow	Exotic	Eurasia	2008	collected	No
Plants	Salicaceae	*Salix fragilis*	Crack willow	Exotic	Eurasia	2008	collected	No
Plants	Salicaceae	*Salix purpurea*	Purple willow	Exotic	Eurasia	2008	collected	No
Plants	Solanaceae	*Solanum dulcamara*	Bittersweet nightshade	Exotic	Eurasia	2008	collected	No
Plants	Trapaceae	*Trapa natans*	water-chestnut	Exotic	Eurasia	1952	collected, established	No
Plants	Typhaceae	*Typha angustifolia*	Narrow-leaved cattail	Exotic	Eurasia	1880	collected, established	No
Plants	Scrophulariaceae	*Veronica beccabunga*	European brooklime	Exotic	Europe	1915	established	No
Platyhelminthes	Planariidae	*Dugesia polychroa*	flatworm	Exotic	Europe	1968	established	Yes
Protozoans	Glugeidae	*Glugea hertwigi*	a microsporidian parasite	Exotic	Europe	1968	established	Yes

Table 29-1.Invasive Species in the Lake Ontario Drainage Basin (Continued)

Group	Family	Scientific Name	Common Name	Exotic/ Native Transplant	Continent of Origin	Year First Collected	Status in Selected HUCs	In vicinity of Either Intake?
Protozoans		*Heterosporis*	Microsporidian	Cryptogenic		2000	established	Yes
Protozoans	Myxosomatidae	*Myxobolus cerebralis*	myxosporean parasite, salmonid whirling disease	Exotic	Europe	1970	established	Yes
Protozoans		*Psammonobiotus communis*	Testate amoeba	Exotic	Eurasia	2002	established	No
Protozoans		*Psammonobiotus dziwnowi*	Testate amoeba	Exotic		2002	established	No
Protozoans		*Psammonobiotus linearis*	Testate amoeba	Exotic		2002	established	No
Viruses.		*Novirhabdovirus sp*	Viral Hemorrhagic Septicemia (VHS)	Native	North America	2006	established	Yes
Viruses	Iridoviridae	*Ranavirus*	Largemouth bass virus (LMBV)	Cryptogenic	Unknown	2000	established	No